

# CMS

## Status Report

M. Della Negra  
RRB22 24 April 2006

**Collaboration News**  
**Construction Progress**  
**Schedule**  
**Financial Plan**

Stat. Rep. Doc: CERN-RRB-2006-031

Compact Muon Solenoid



# New Groups approved in CMS

## 6 new US Groups:

	<b>Presented</b>	<b>Approved</b>
1. Lawrence Livermore Nat. Lab (LLNL), Doug Wright,	Sep05	Dec05
2. SUNY at Buffalo, A. Karchilava,	Sep05	Dec05
3. Texas A&M University (TAMU), David Toback	Sep05	Dec05
4. Purdue Calumet, Neeti Parashar	Sep05	Dec05
5. University of Puerto Rico, Angel Lopez	Dec05	Mar06
6. Rockefeller Univ., Anwar Bhatti	Dec05	Mar06

## 3 new non US groups:

	<b>Presented</b>	<b>Approved</b>
1. Frascati (INFN, Italy), Stefano Bianco	Sep05	Dec05
2. Universidad de los Andes Bogota (Colombia), C. Avila	Dec05	Mar06
3. DESY, Hamburg (Germany), J. Mnich	Dec05	Mar06



# Spokesperson Election

## **New rules (approved by CB 17 Feb):**

- The term of office should be two years.
- The election for the term starting in Jan 20NM should be held in Dec 20NM-2, to allow the “Spokesperson Elect” to become familiar with the demands of the job.
- A person may not serve two consecutive terms as Spokesperson.  
(A Deputy may become SP for the following term, but not the reverse)
- Exceptionally and uniquely, the first term under the new rules, starting in Jan 2007, should be for three years, to oversee the transition from construction to operation.

## **Election 21st June; three candidates :**

- Dan Green (FNAL, US)
- Gigi Rolandi (CERN)
- Jim Virdee (Imperial College, London, UK and CERN)



# Technical Coordination

- ❑ Alain Hervé has decided to step down as Technical Coordinator, ending his mandate in March 06. His main reason is to push the younger people in the TC team to take responsibility for the end of the construction phase, while he is still around.
- ❑ As a consequence and in agreement with the CERN Management, I have nominated Austin Ball as the new CMS Technical Coordinator for the period 20 Mar 06 to 31 Dec 06. This change was approved by the CMS Collaboration in the last CMS week (13-17 March).
- ❑ Alain will continue as the Magnet and Infrastructure Project Manager.



# Construction Progress since Oct 05 RRB

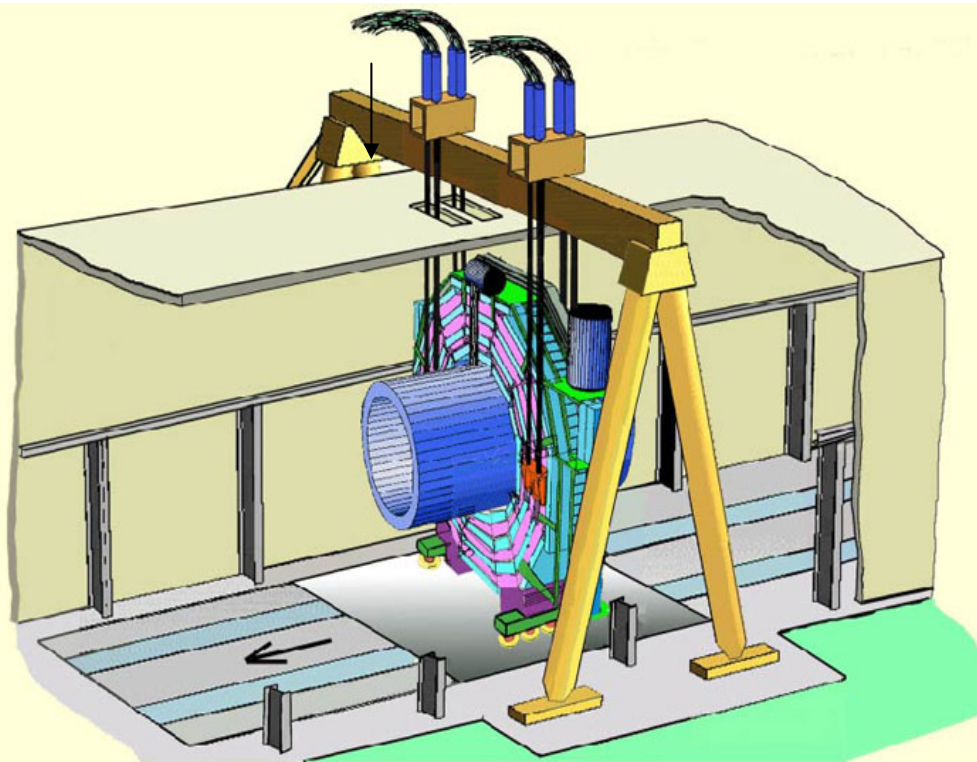
**A great deal of progress has been made since Oct 05 RRB.**

- ❑ The 4 Tesla superconducting coil is now cold, at liquid Helium temperature 4.5°K.
- ❑ The new Tracker Integration Facility (TIF) is in operation since end 05.
- ❑ 78% of barrel crystals delivered. 22/36 bare Supermodules (1700 xtals) assembled. Electronics integration proceeds at a rate of 1 SM/week. 9 out of 36 SM integrated so far.
- ❑ HCAL source calibration complete. HCAL pre-calibrated to ~ 4%
- ❑ Over 3 out of 5 wheels worth of DT/RPC packages installed. > 90% of CSCs installed on endcap disks. Half of endcap RPCs installed.
- ❑ Physics TDR Vol1 (detector performance) submitted to LHCC in Jan.
- ❖ **Commissioning with cosmics of large sub-parts (systems tests) has started. Cosmics have been recorded for all sub-detectors: TK, ECAL, HCAL and Muon system.**
- ❖ **Next important milestone: Magnet test and Cosmic Challenge of a full slice of CMS (Jun-Aug 06).**



# Transfer CMS Underground in 2006

Gantry installed over PX56. Load test of pit cover 2500t: Apr06  
Load test of crane: May06. HF lowering: Jul06



YB0 lowering (2000t): Oct 06





# Floor plates have been precisely aligned wrt beam



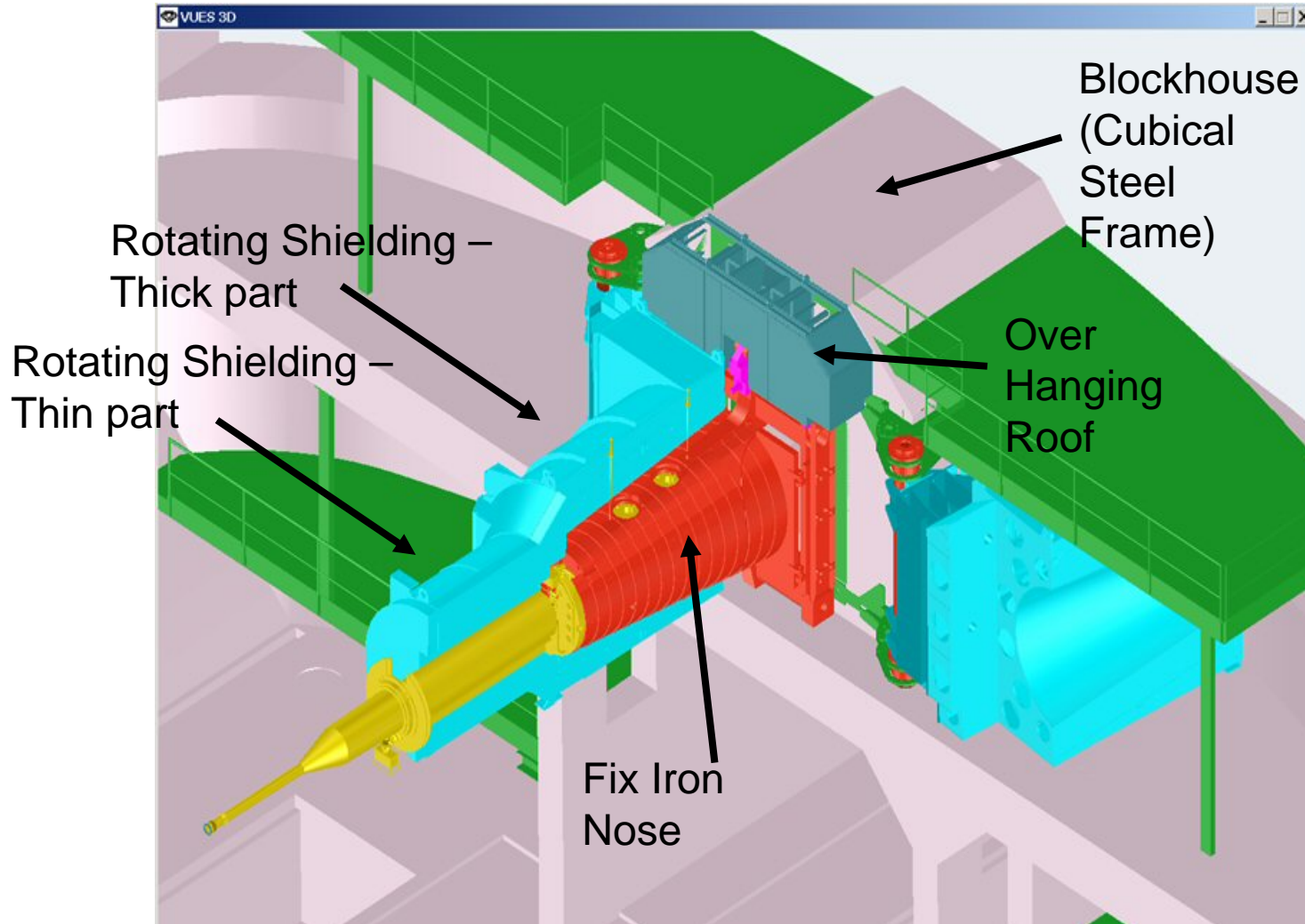
*Trench for HF cable chains*

*Trenches for YE1 & YB cable chains*

*Steel plates have been welded and grouted to allow air pads to travel easily*



# Next Operation is installation of Forward Shielding







# Installation of Cubical Steel Frames

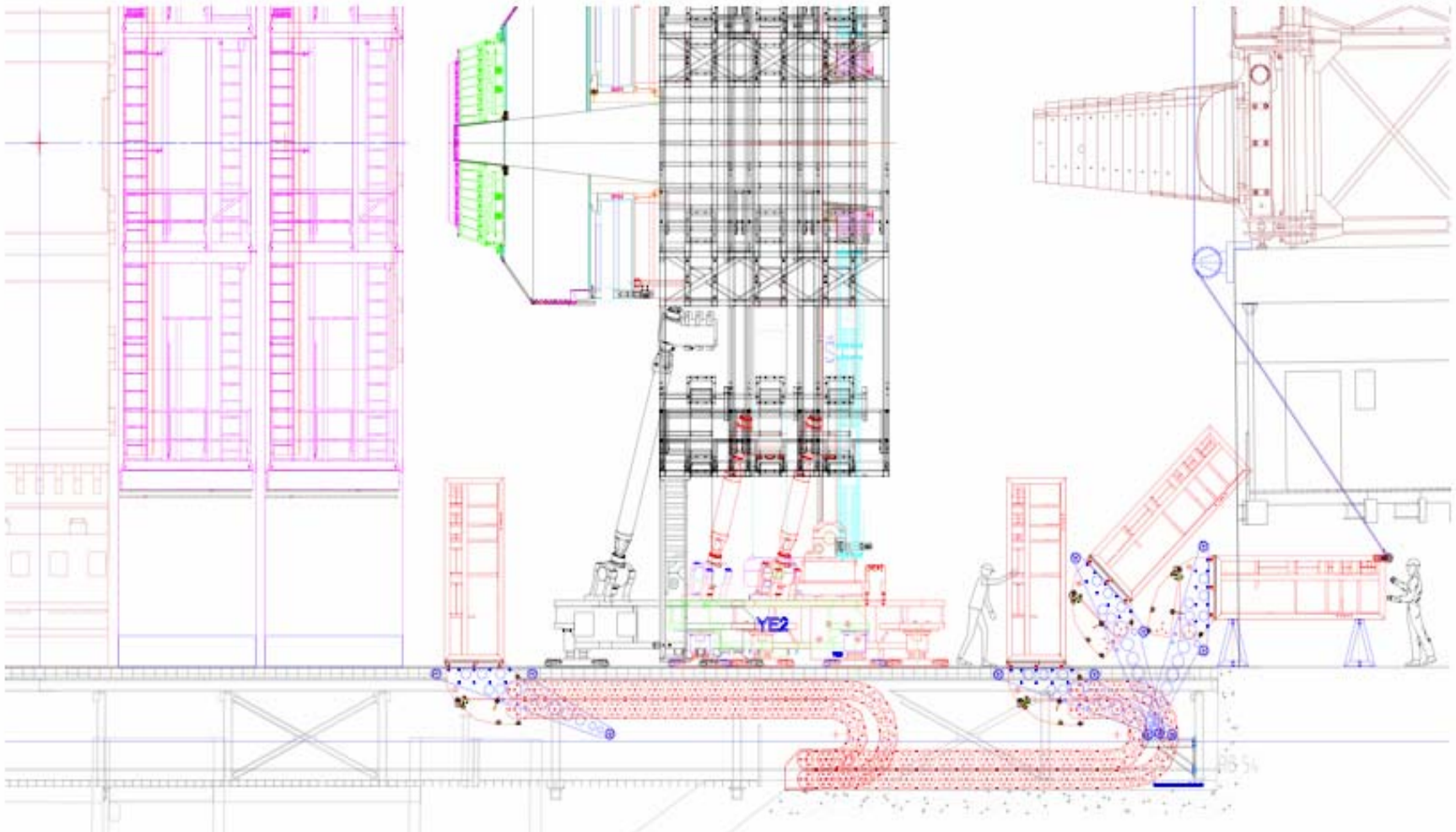


*First CSF in position under main pit*

*Second CSF being transported across UX5 opposite to main pit.*

*This is the first load being transported across UX5 using the air pads on the steel plates.*

# Cable Chains



UXC cable Chains installed: April 06- June 06

# CMS Solenoid

Swivelling of coil 25 Aug



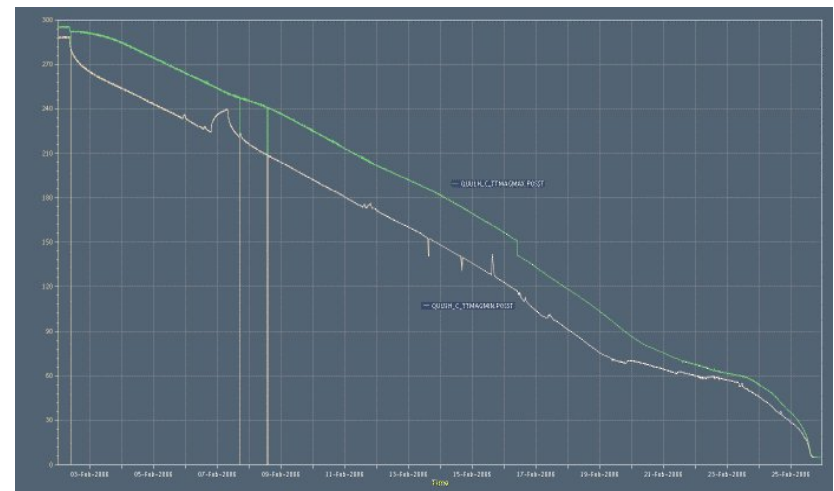
Coil inserted 14 Sep.



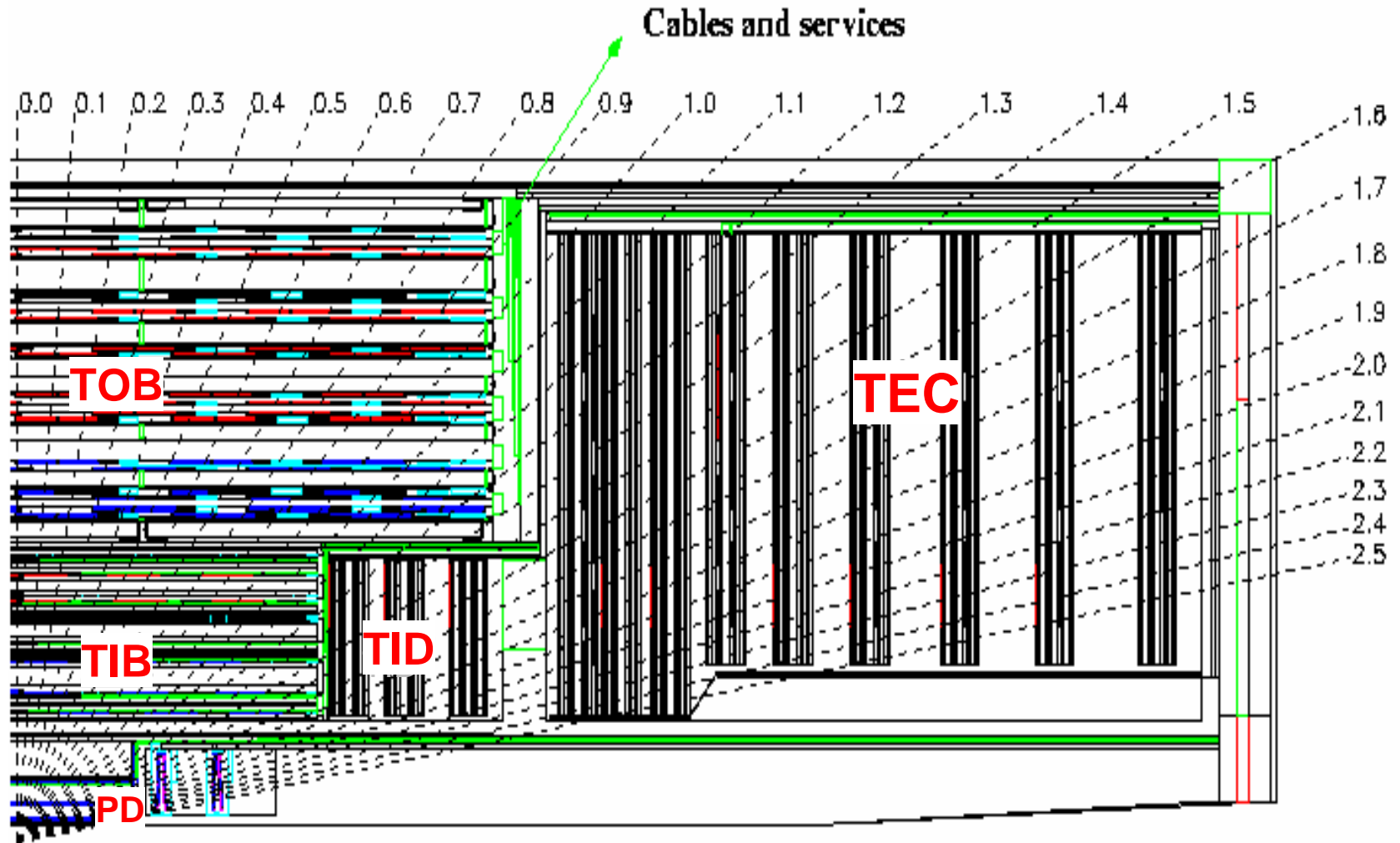
Vacuum Tank welded (Nov-Jan)



Coil Cooled to 4.5K in 25 days (Feb).  
Test on Surface (May-Aug)



# Inner Tracker





# Tracker Integration Facility (TIF) at CERN

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

- ❑ Integrate all of the Tracker at CERN (TOB, TEC & TIB) in 2006
- ❑ 'Standard' Electronics and DAQ Systems available for 25% of the channels
- ❑ Commissioning May 06-Jan 07. Transport to Pt 5 end Jan 07.



# The Tracker Support Tube in the TIF

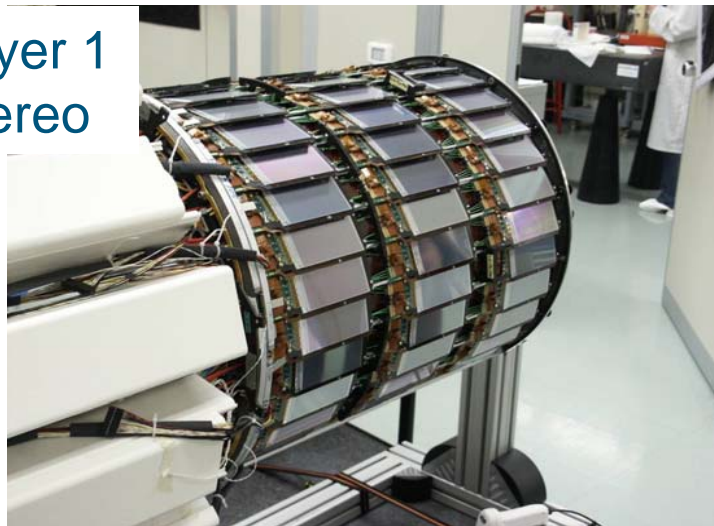
QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.



# TIB integrated in Italy

TIB/TID+ moved to CERN 30 May. TIB/TID- at CERN in August. Start full TIB+ commissioning at CERN in June (TIF).

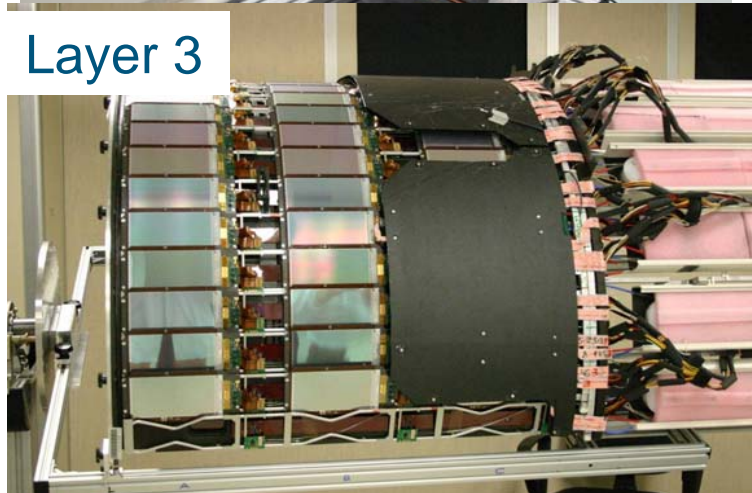
Layer 1  
Stereo



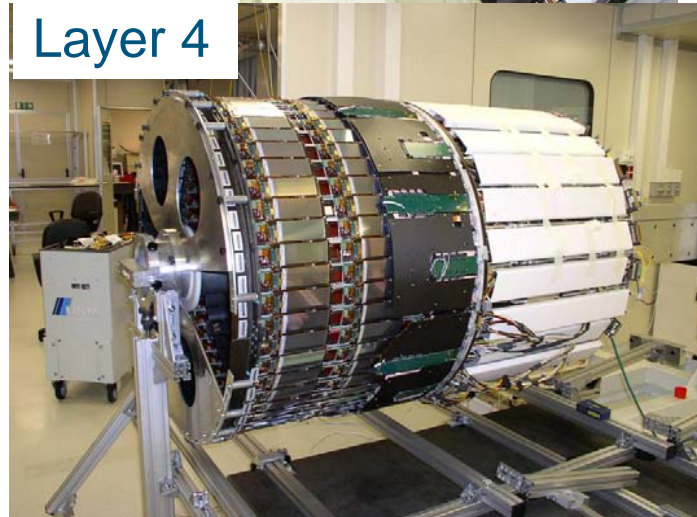
Layer 2  
Stereo



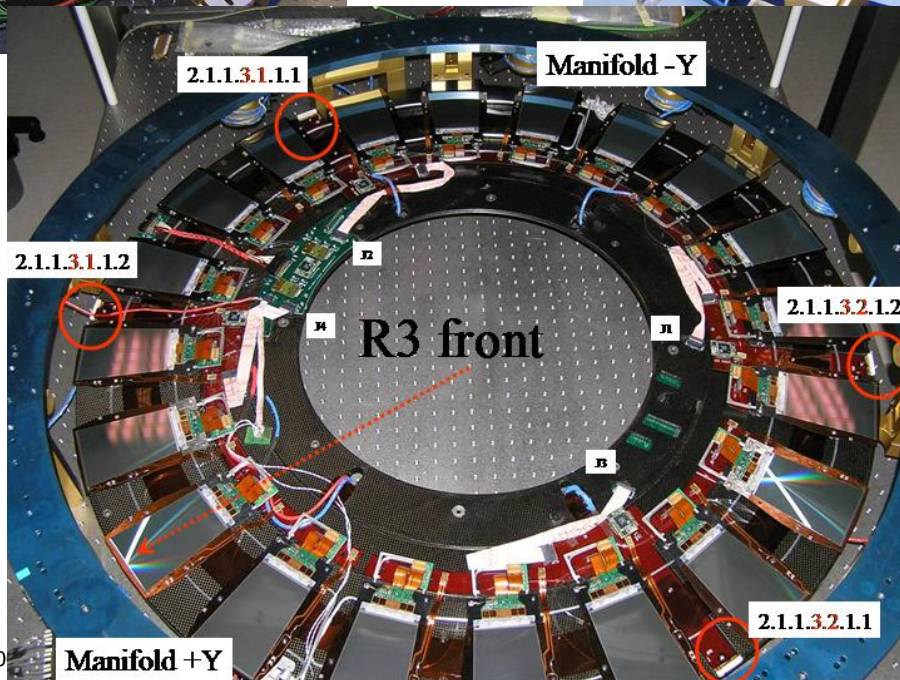
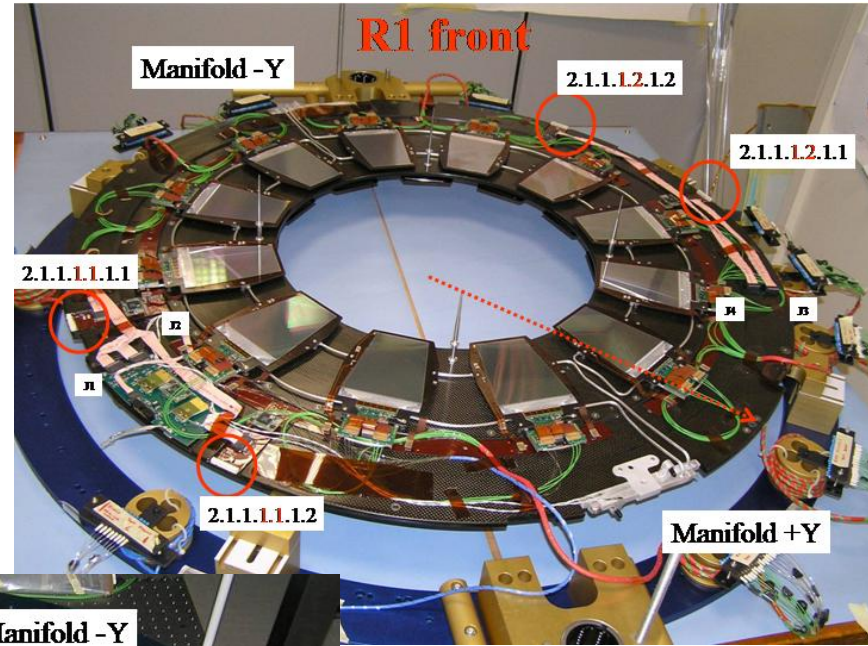
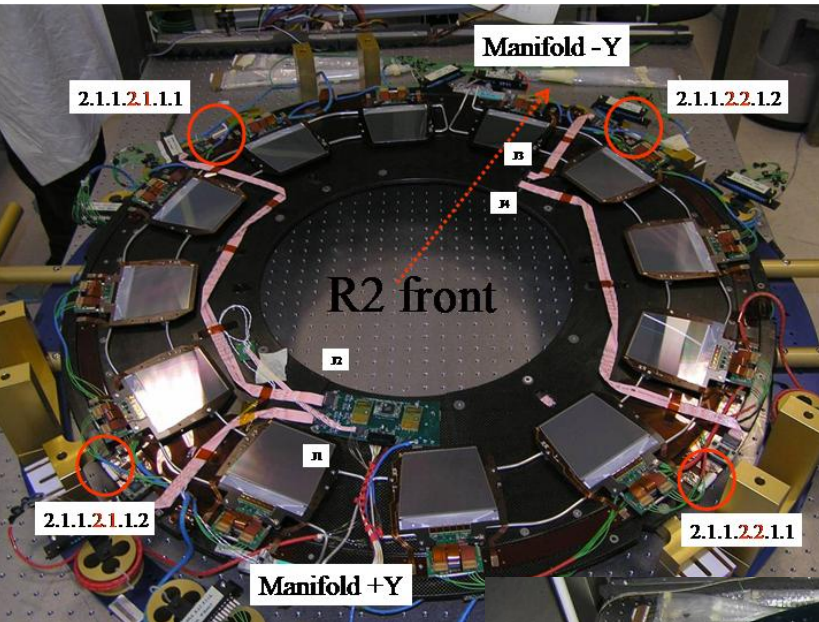
Layer 3



Layer 4



# TID components: the rings







# TOB: Rods insertion and cabling in TIF

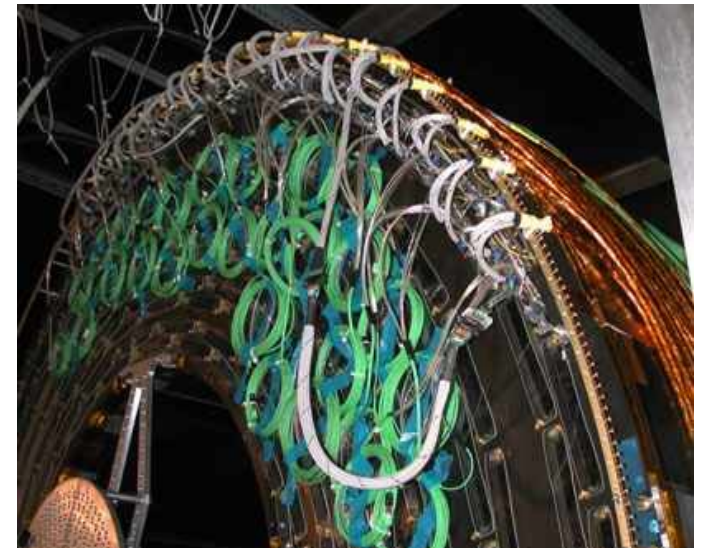
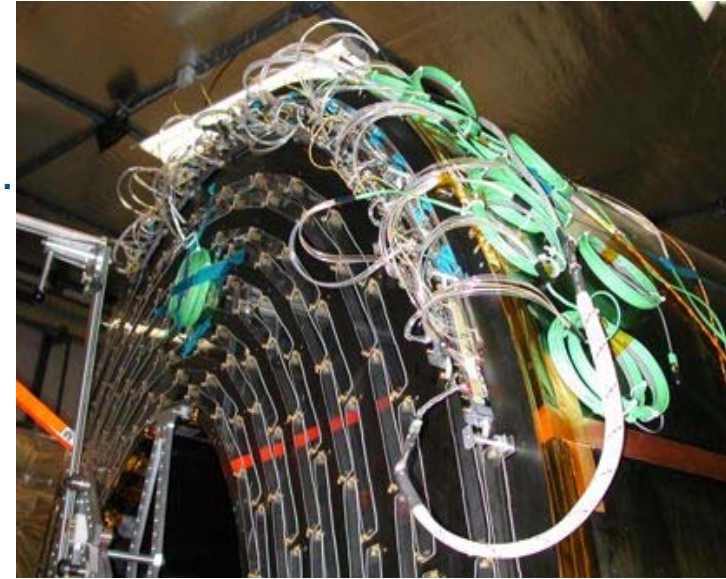
6 layers of Rods.

Today : 97 rods integrated/688 (14%);

38 rods validated (2 cooling segments / 44)

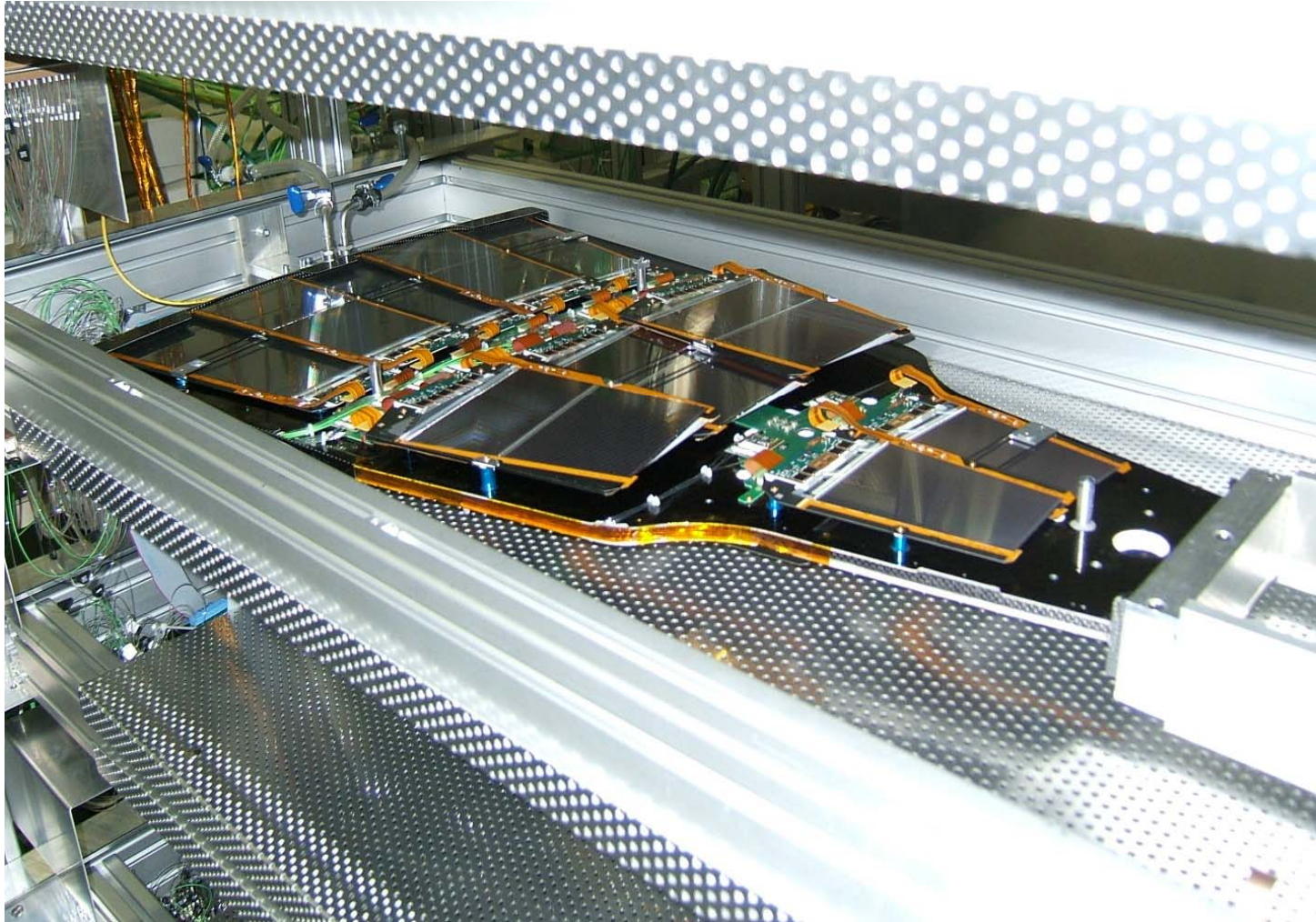
Rods are produced at a rate of 40 rods/week in US.

TOB+ complete: Aug, TOB- : Oct with shift operation.



# TEC: Petals

Today : 155 petals integrated/300 (50%) ; petals produced at a rate of 10petals/week (Fr, Ge, Be).



## TEC- at CERN

18 petals integrated  
qualification in progress



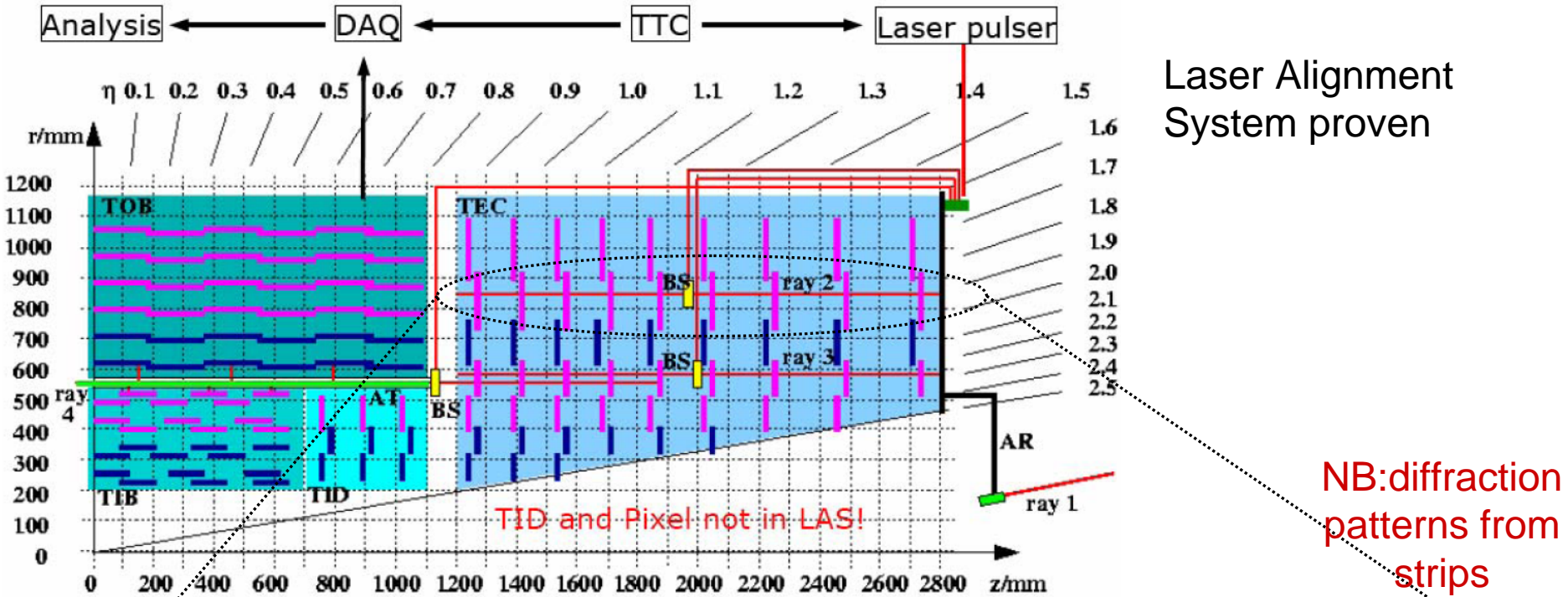
## TEC+ at Aachen

54 petals integrated  
1 sector of 18 fully qualified.

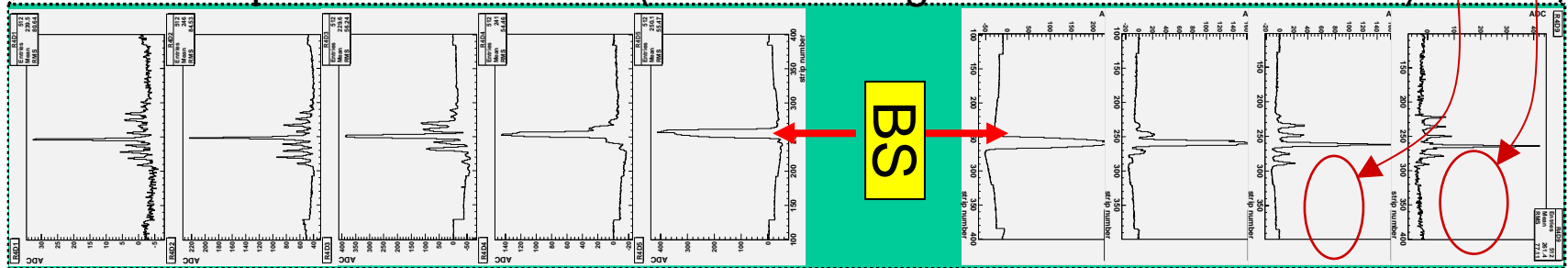


- ❑ Each TEC is made of 9 disks.
- ❑ TEC+ complete: Sep, TEC- complete: Nov
- ❑ TEC integration is critical. Aim to gain ~ 1 month.

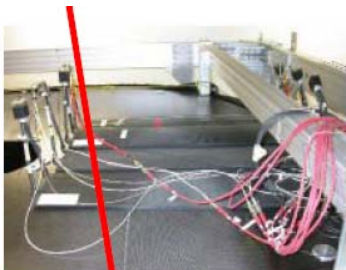
# Laser Alignment System



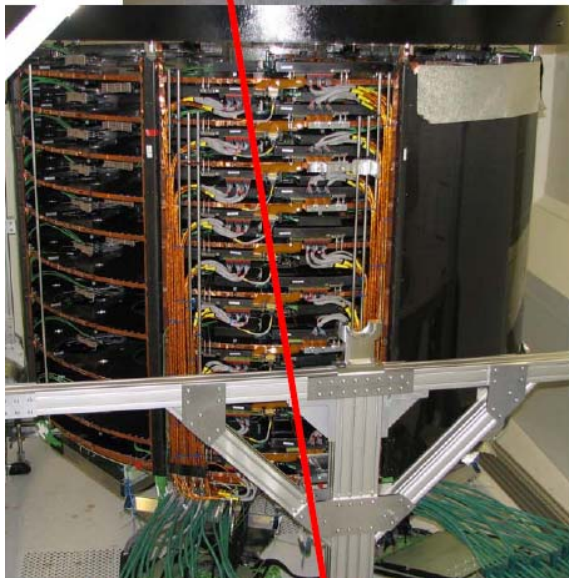
Laser profile in all 9 disks (laser at “full” gain to illuminate all disks)



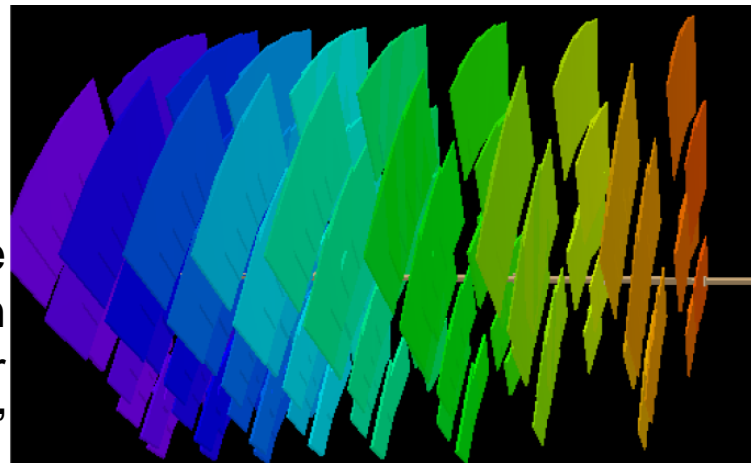
# TEC Verification with Cosmics



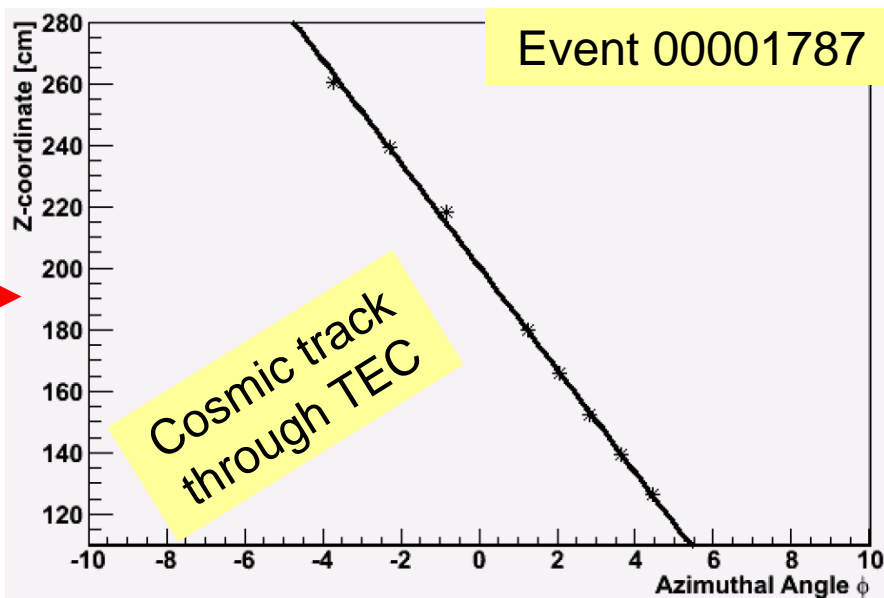
Scintillator panels above and below for triggering



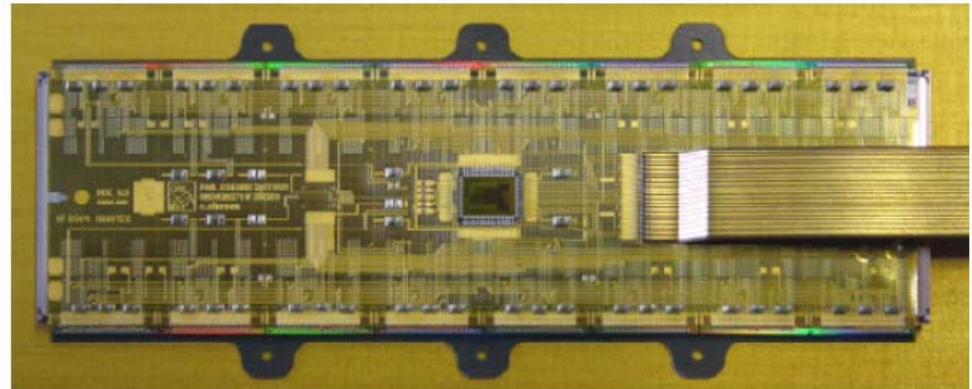
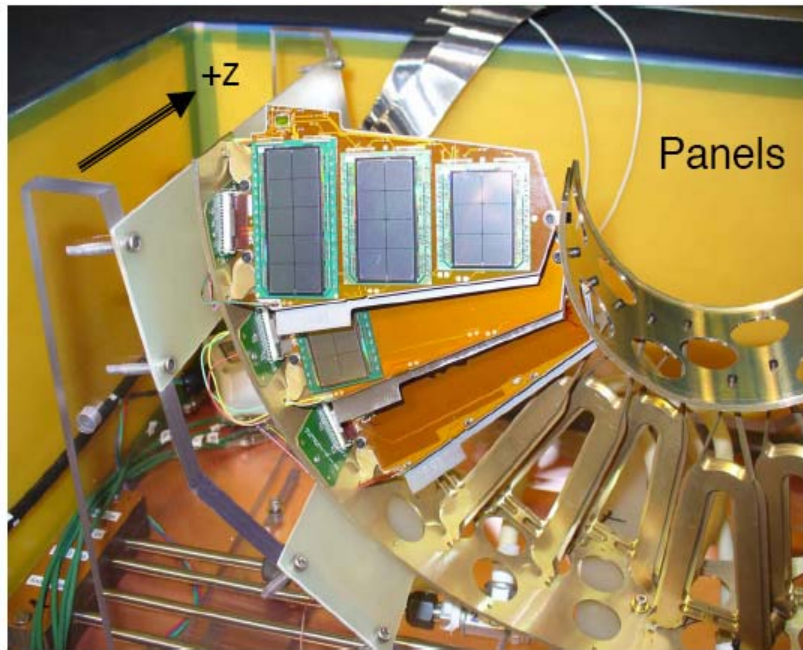
Tracker Endcap (TEC)



Software reconstruction of a "Laser track"



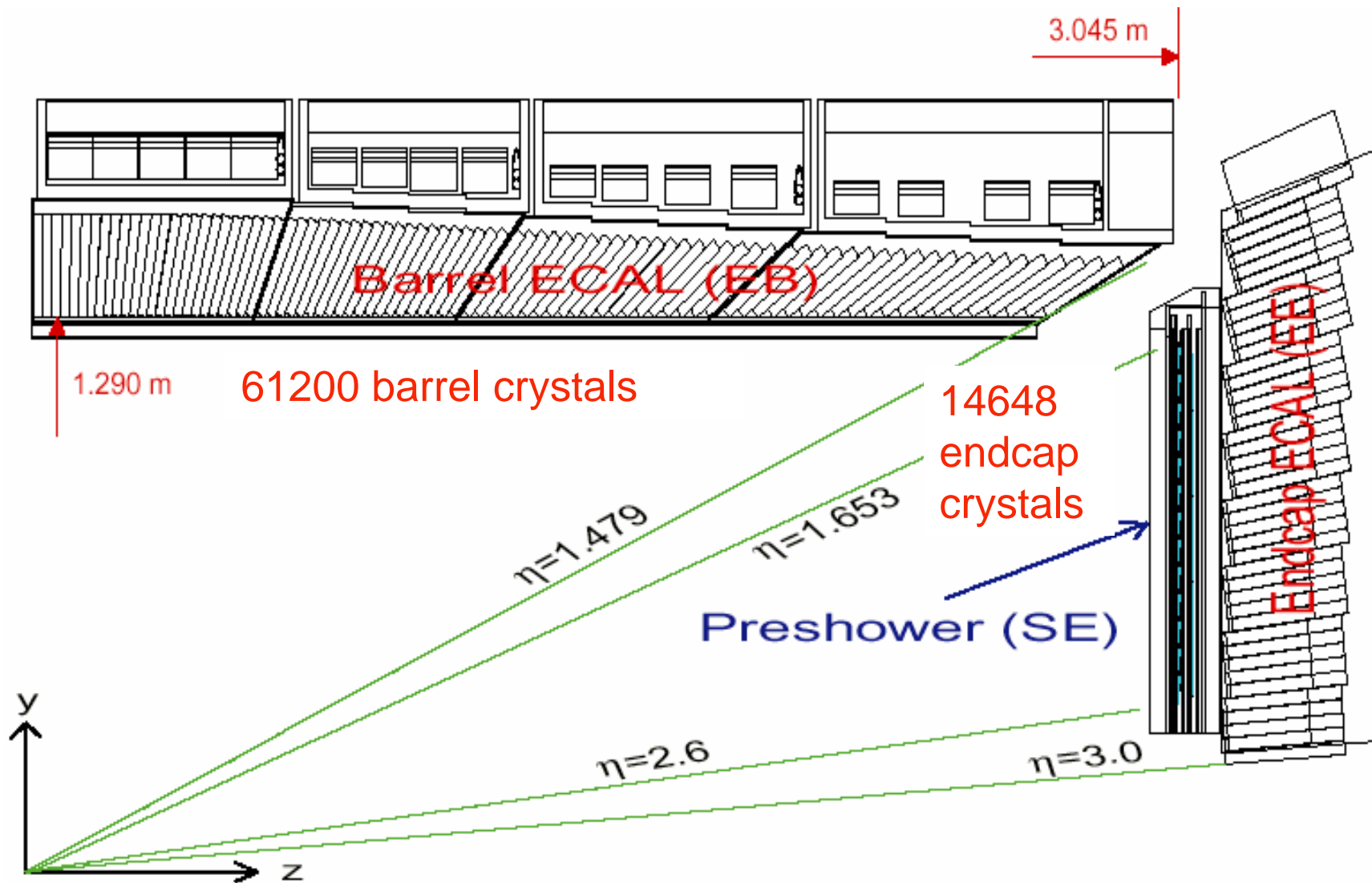
- ❑ Full Pixel system (3+2) installed for the 2008 physics run.
- ❑ Install a phi-section for Pilot run in 2007
- ❑ ROC chip recently became available.
- ❑ Bpix module fabrication started. Milestone: 1/3 done by Sep
- ❑ Commission Fpix in CERN 2nd half-07

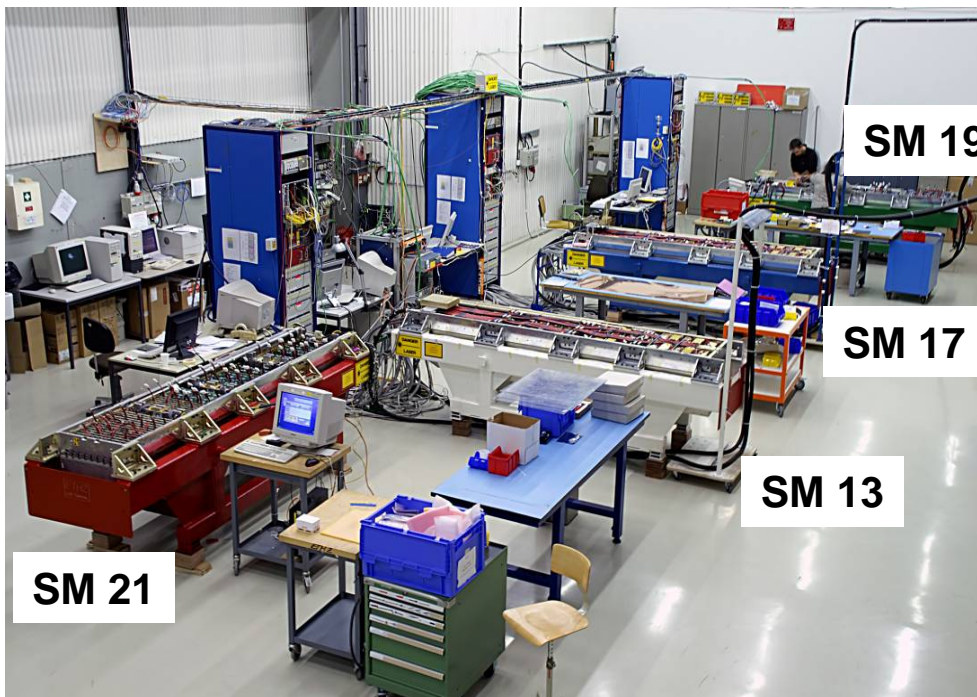


3 Barrel layers (L1 at 4cm)

720 Barrel modules

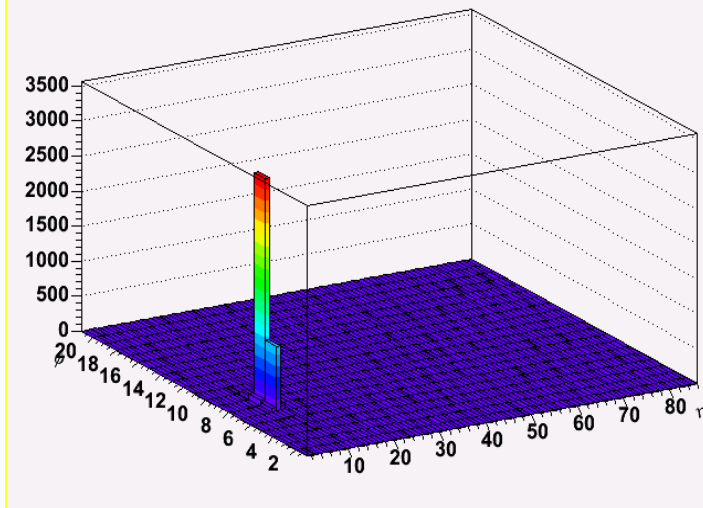
2 endcap disks, 672 Endcap modules





22/36 bare SMs assembled.

Event: 4161 cry: 168



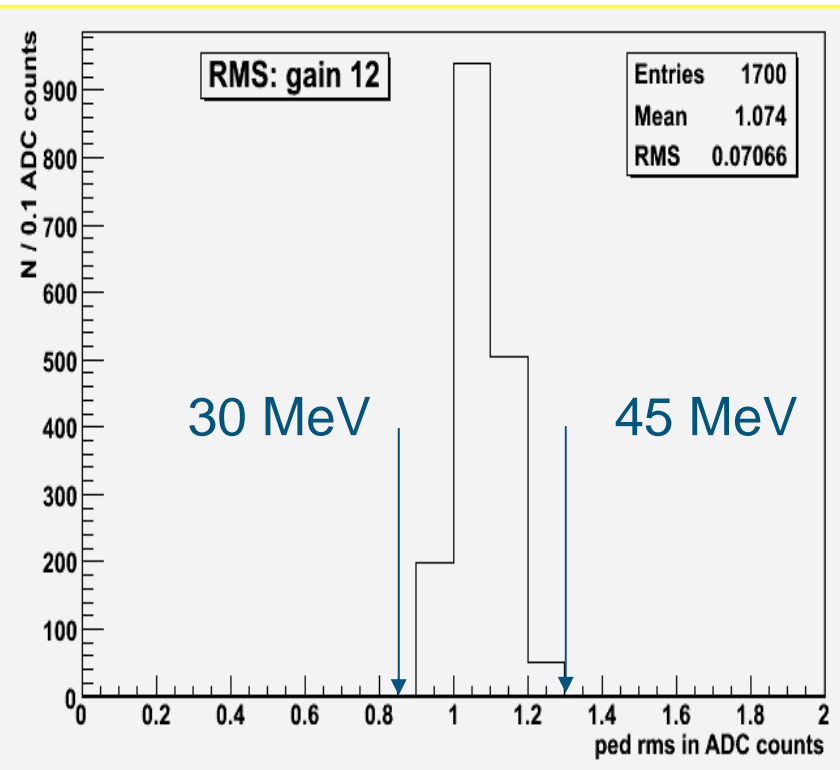
Cosmic track through an ECAL SM

- ❑ 4 assembly teams work in parallel to integrate 4 SM/month.
- ❑ 9 out of 36 Supermodules integrated.
- ❑ Every integrated Supermodule is pre-calibrated with cosmic rays for ~ 1 week.
- ❑ 3% absolute calibration achievable with cosmics.

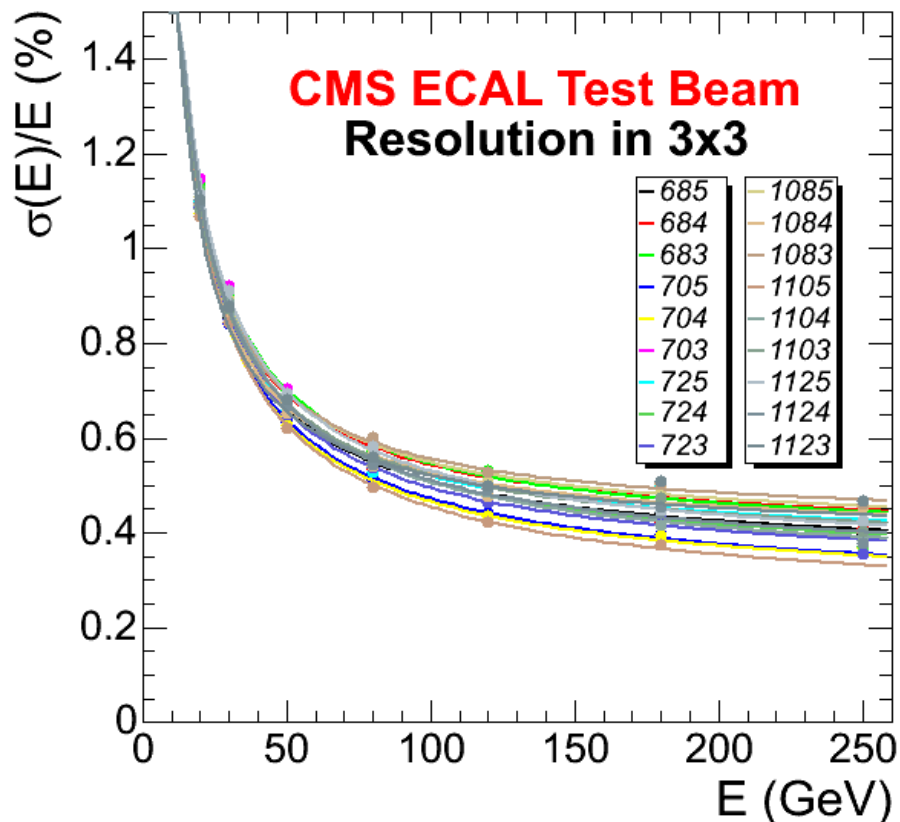




# ECAL performance



Noise distribution of the 1700 channels of SM13



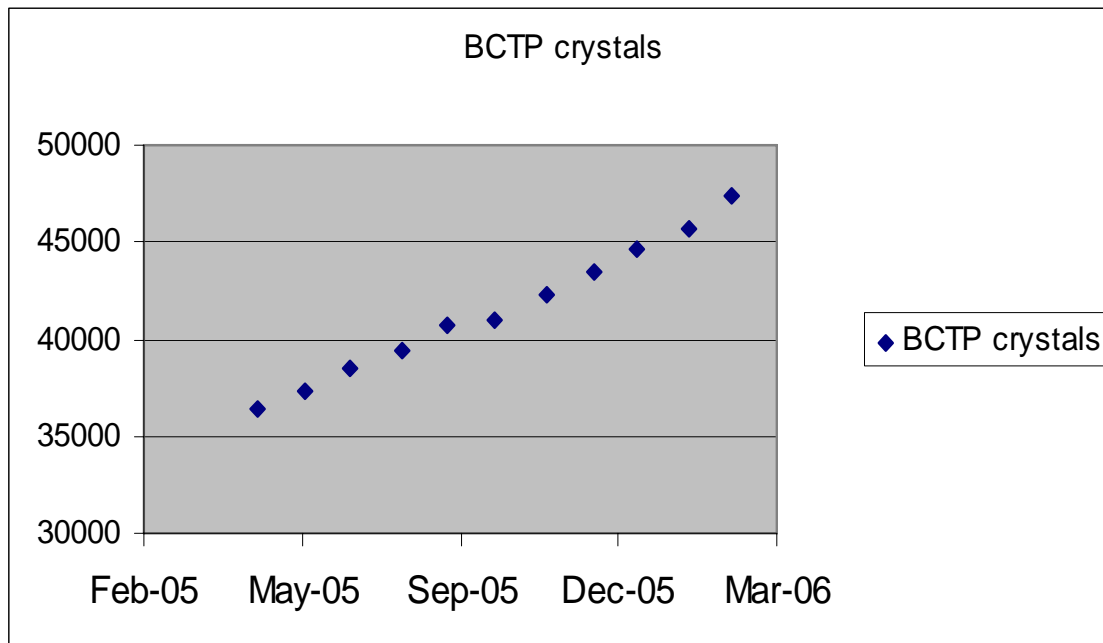
Energy resolution:  
Final results from 2004 test beam  
for uniform coverage on 18 crystals



# Crystals Production and ECAL Schedule

## Crystals delivery determines ECAL Critical Path.

- ❑ 78% of usable Barrel crystals in hand (48,130/61,200).
  - ❑ 47,470 BCTP @ 1100/mo of good quality (0.1% rejects)
  - ❑ 660 SIC @ 130/mo, after 2 mo stop, quality improving (<10% rejects).
- ❑ Last ECAL Barrel crystal delivered February 2007.
- ❑ Last ECAL Endcap crystal delivered January 2008.



### BCTP production:

- ❑ Contractual rate: 1100/mo
- ❑ Reached 1140/mo in the past 3 mo.
- ❑ Hope to further increase the rate



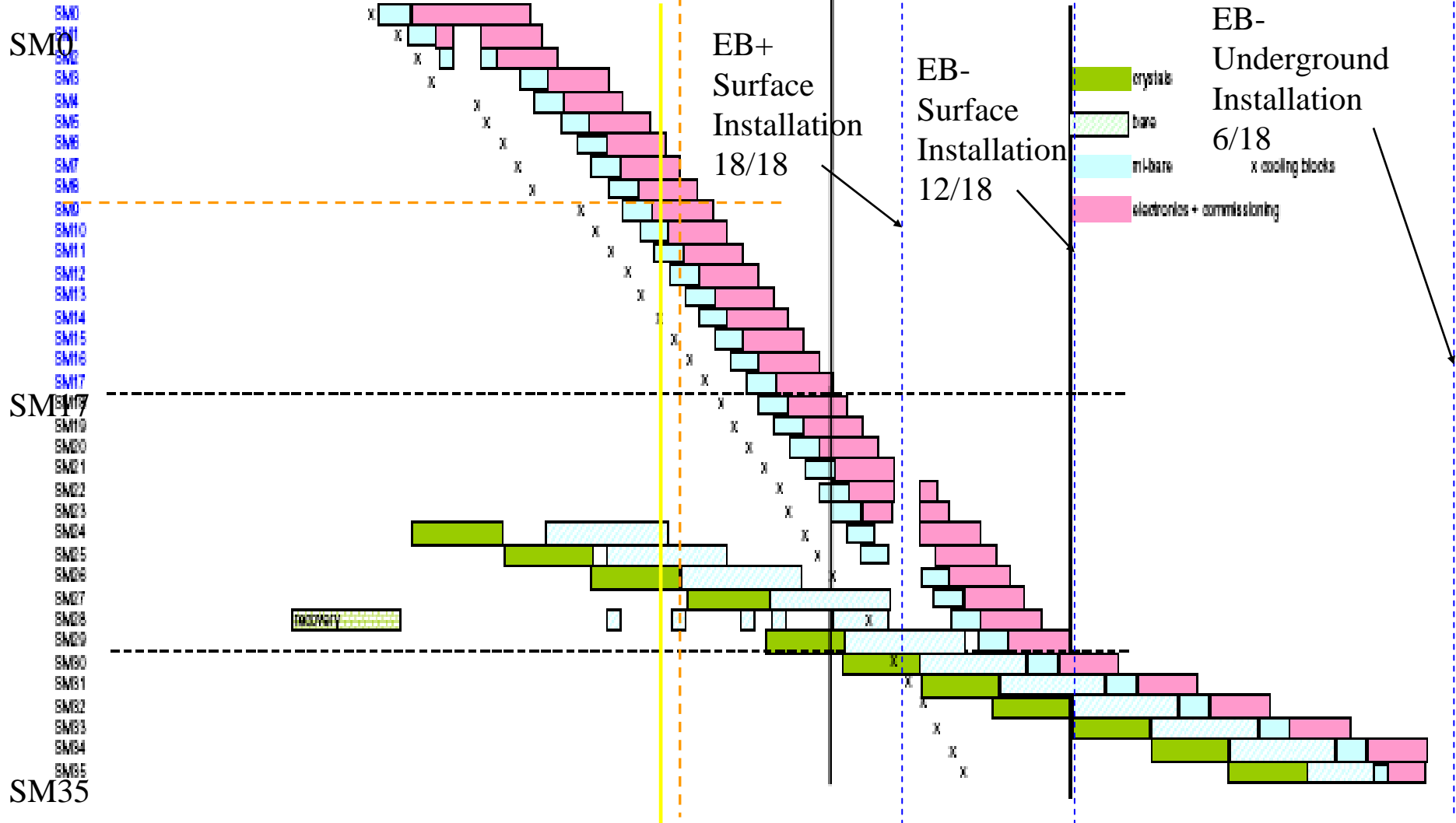
# ECAL Barrel Dashboard

05

06

07

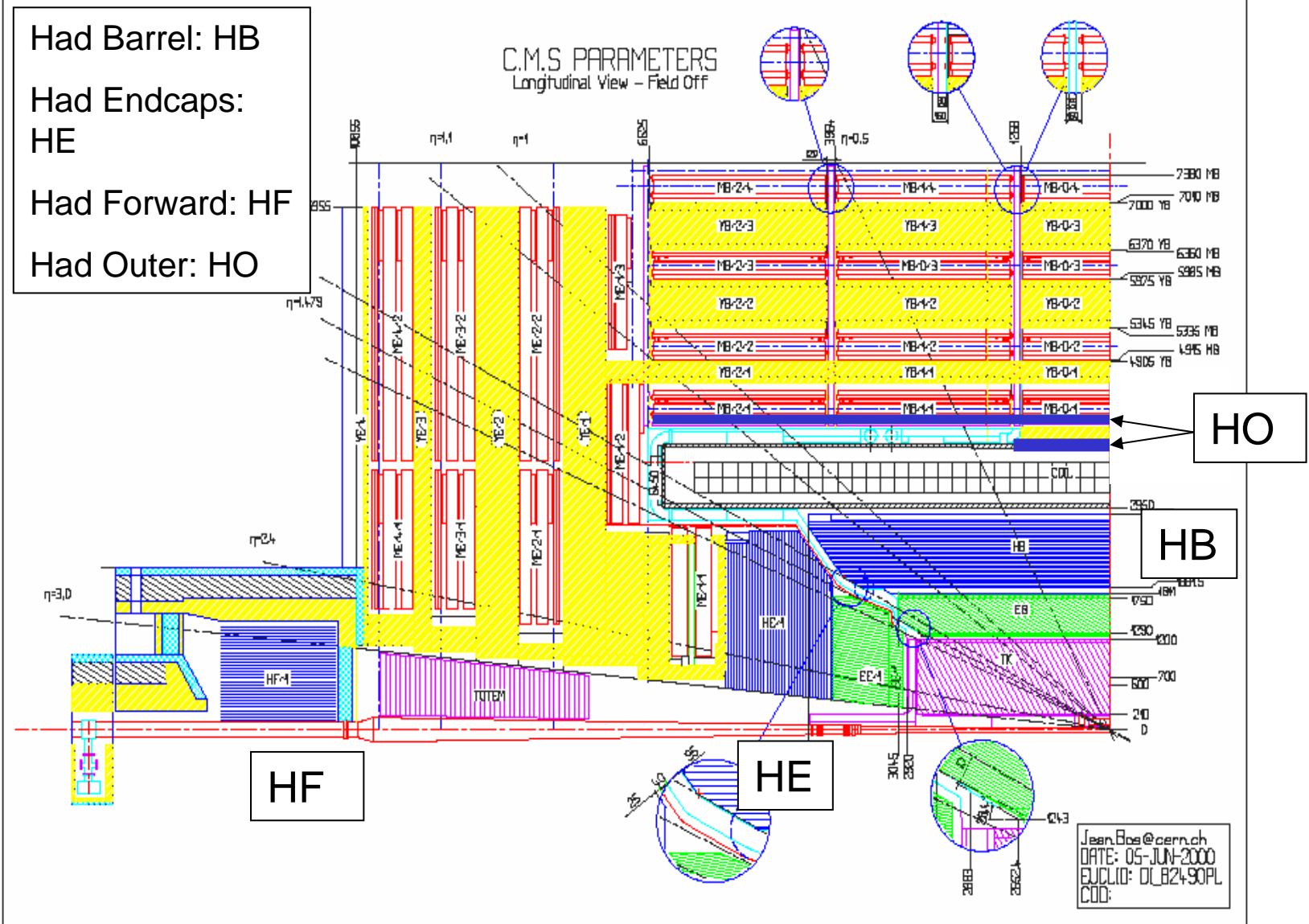
July August September October November December January February March April May June July August September October November December January February March April May



# Testing ECAL SM insertion

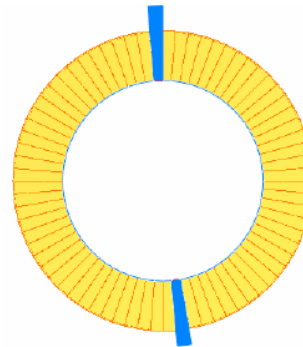
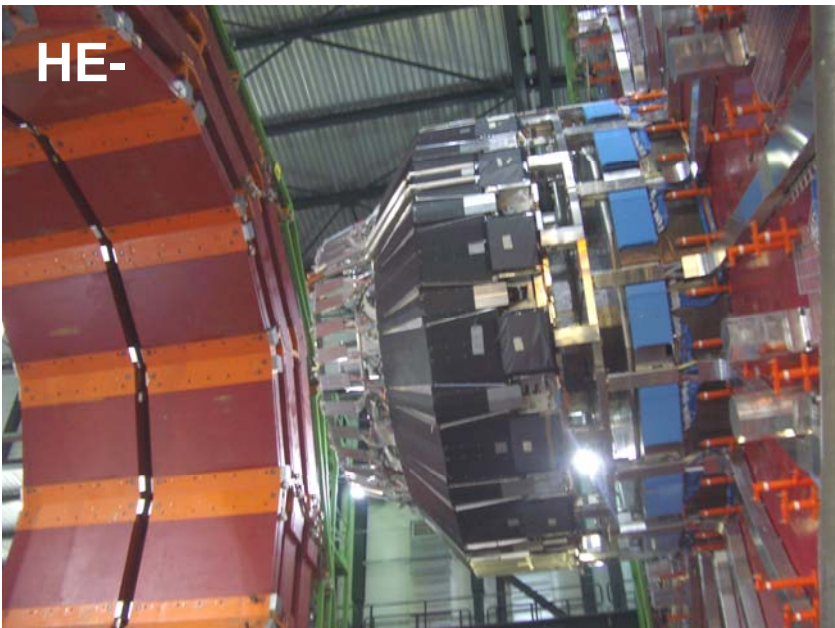
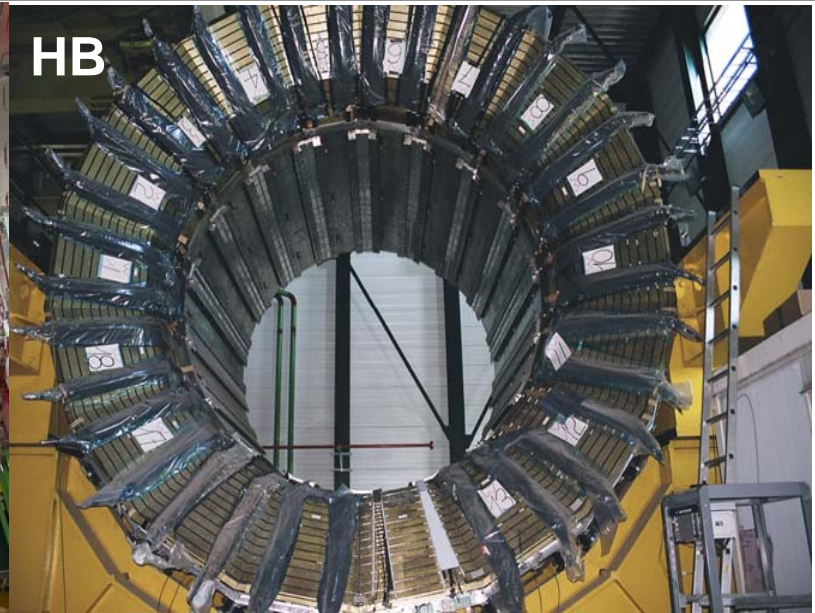
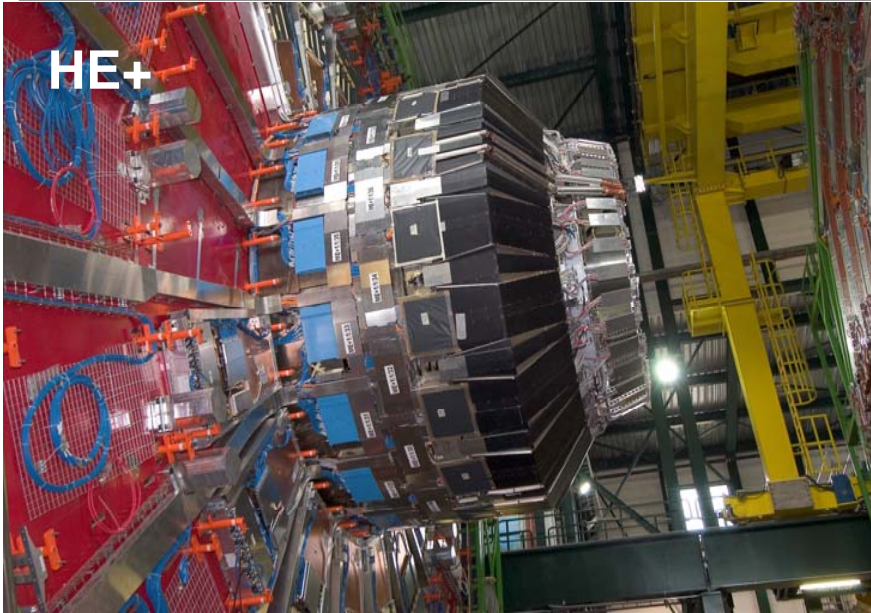


# Hadronic Calorimeter: HCAL

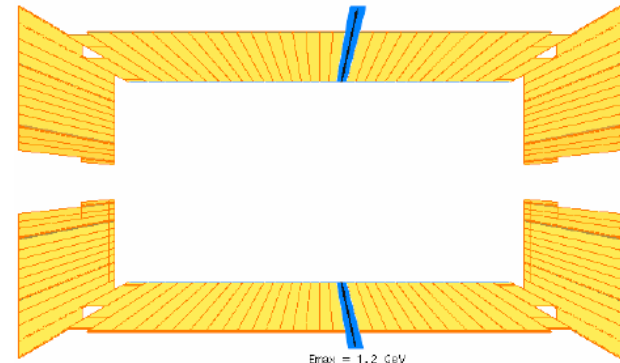




# HCAL Source Calibration done: HB and HE



Cosmics seen!

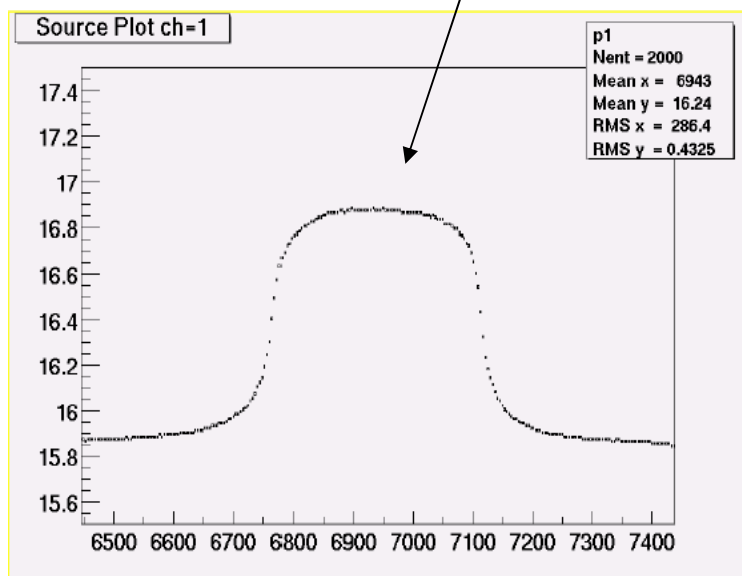




# HCAL Source Calibration

Each Scintillator tile in every layer is calibrated with a moving wire  $^{60}\text{Co}$  5mCi source.

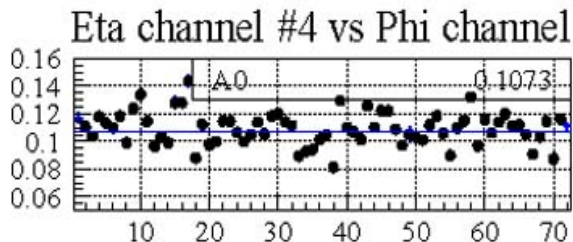
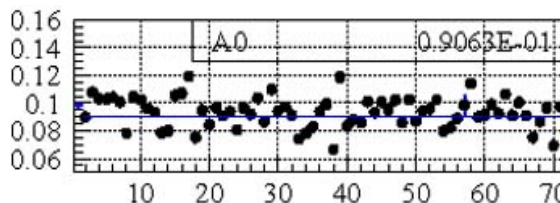
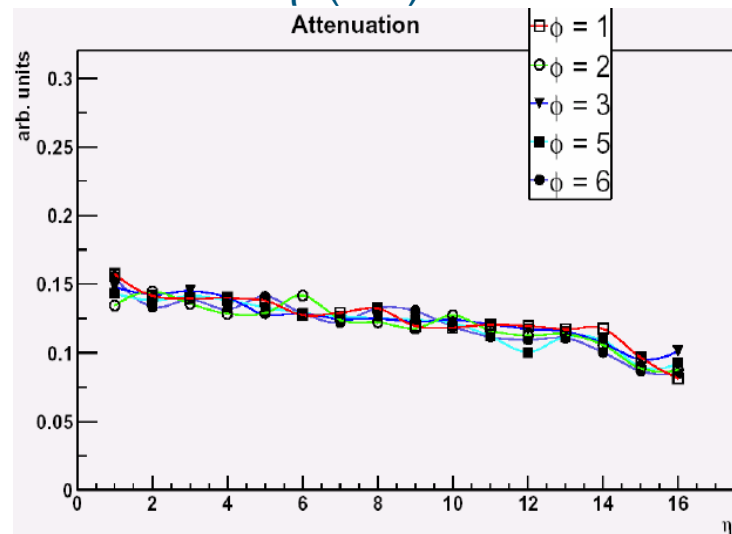
Response of a scintillator tile as the radioactive source passes by it.



**HB/HE pre-calibration to ~ 4%**

**HF pre-calibration to ~ 5%**

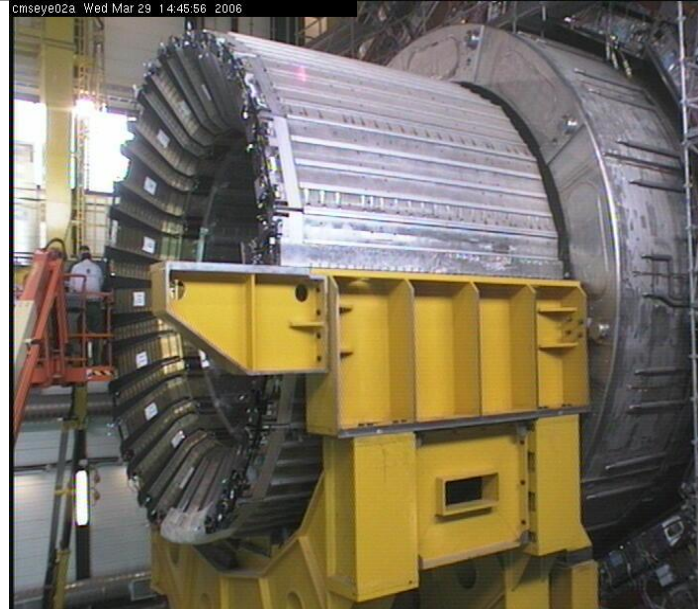
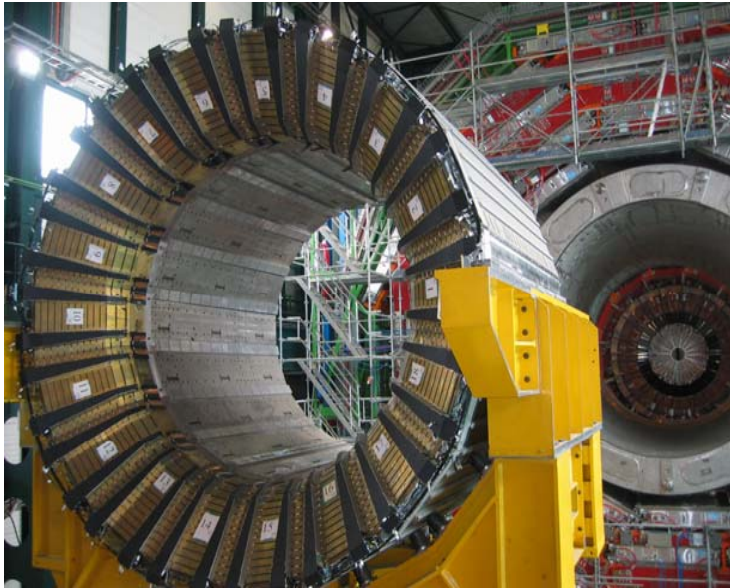
Attenuation due to variation of fiber length between tile and HPD as function of  $\eta$  (HB).



Scatter around A0 gives the calibration coeff: Tile response x gain of HPD



# HB+ insertion complete on 3 April





# HB- ready for insertion (24 Apr)

cmseye01 2006-04-24 07:59:43





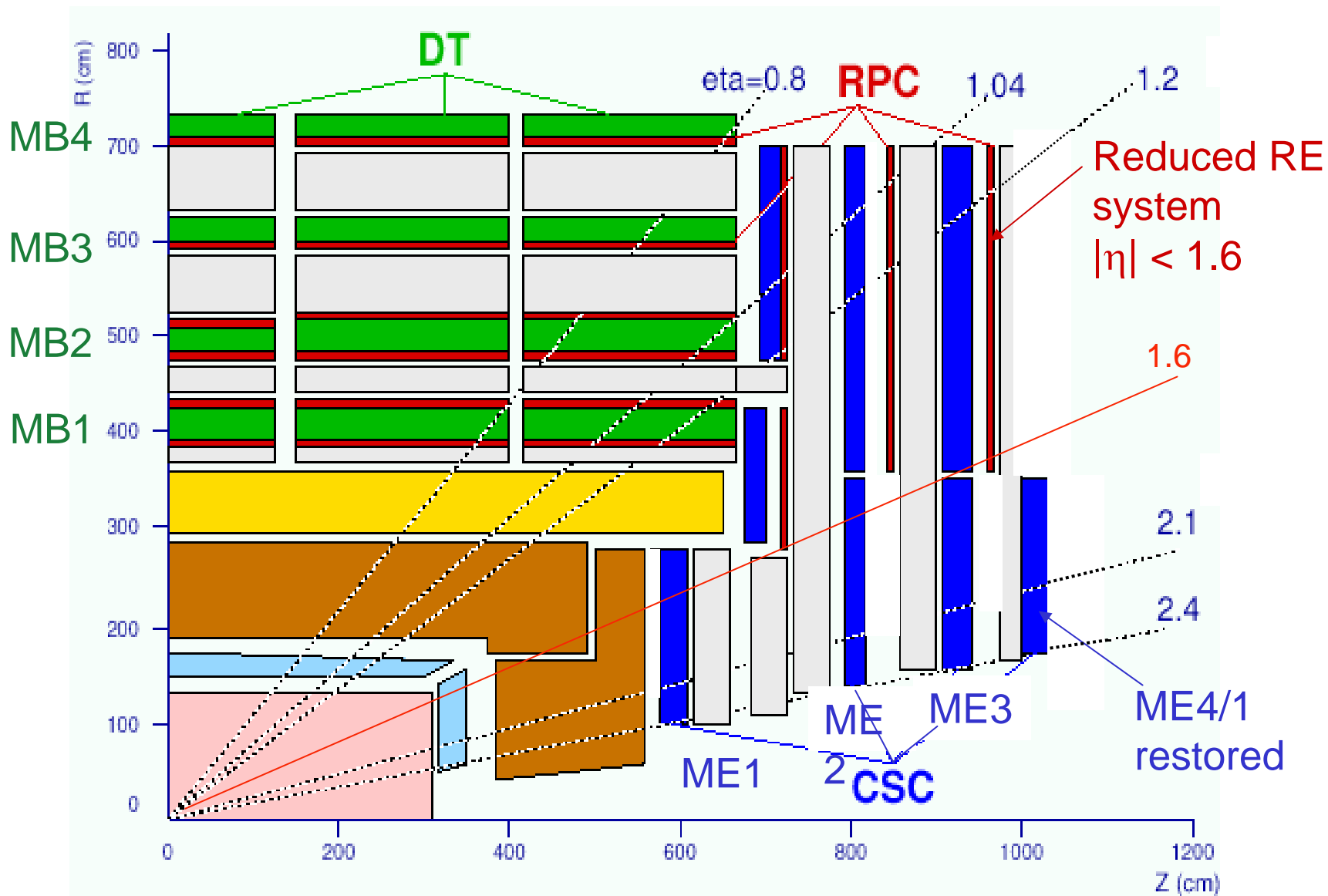
Being source  
calibrated

source calibrated

**Lower HF in July**



# Muon System

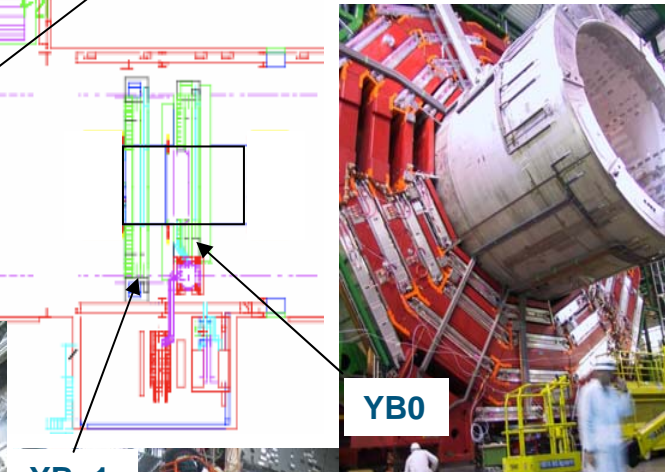
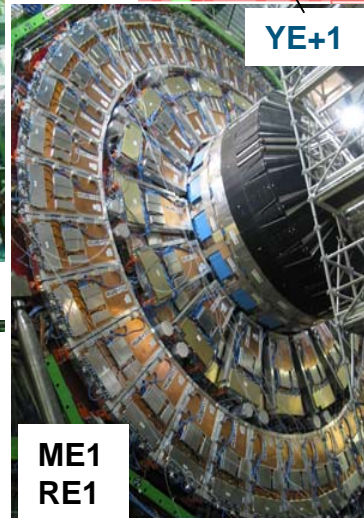
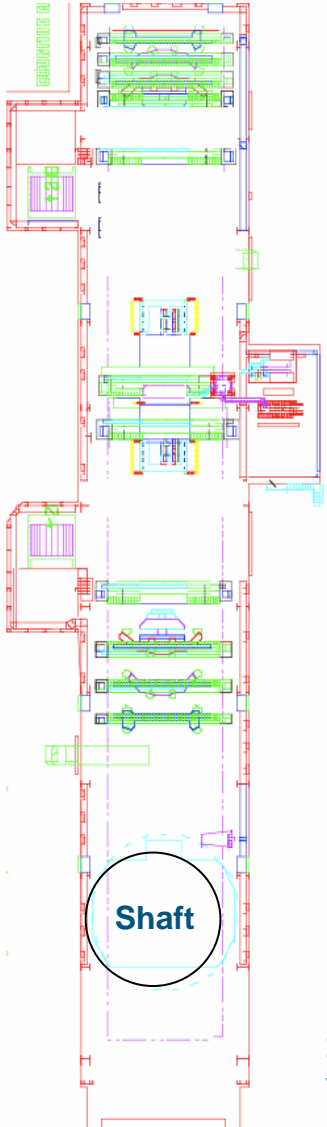




# Muons Installation and Commissioning

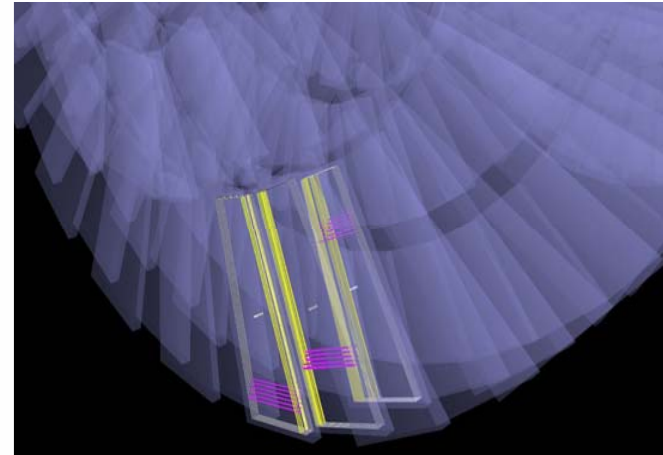
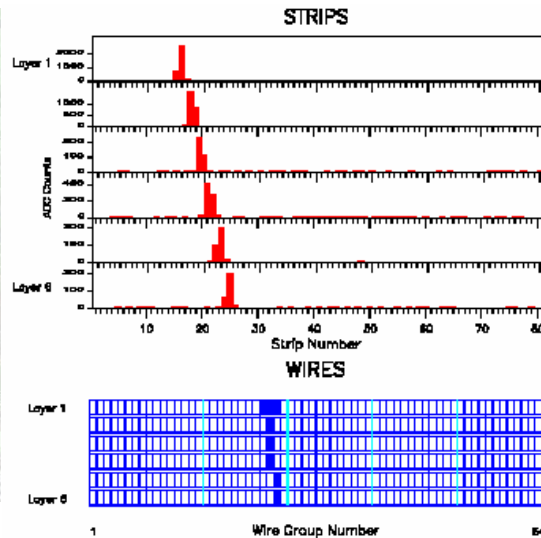
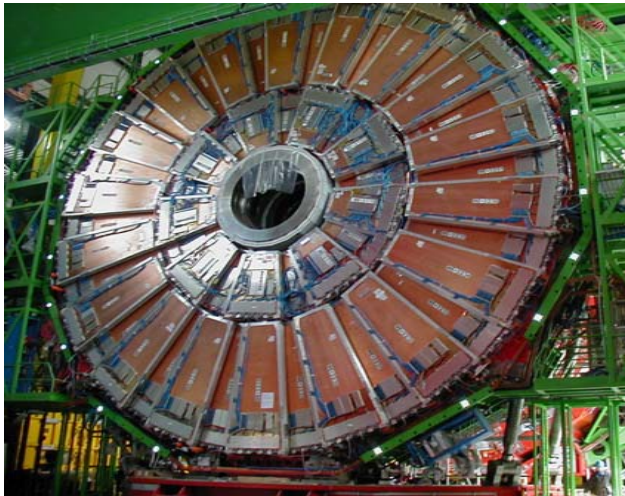
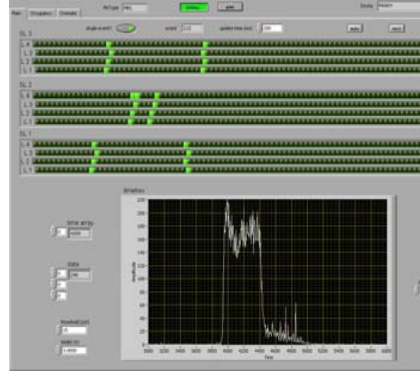
Surface Hall  
SX5

50% of RPCs  
installed on YE disks.



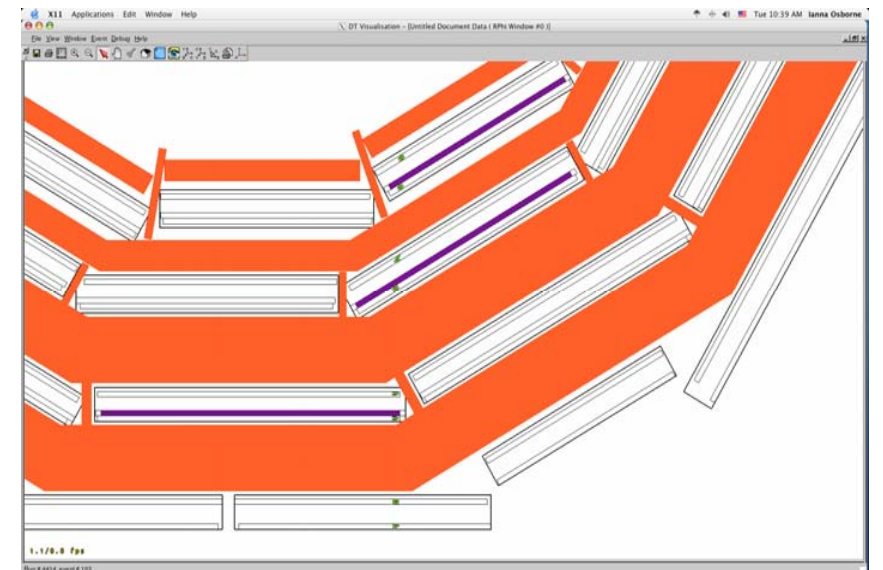
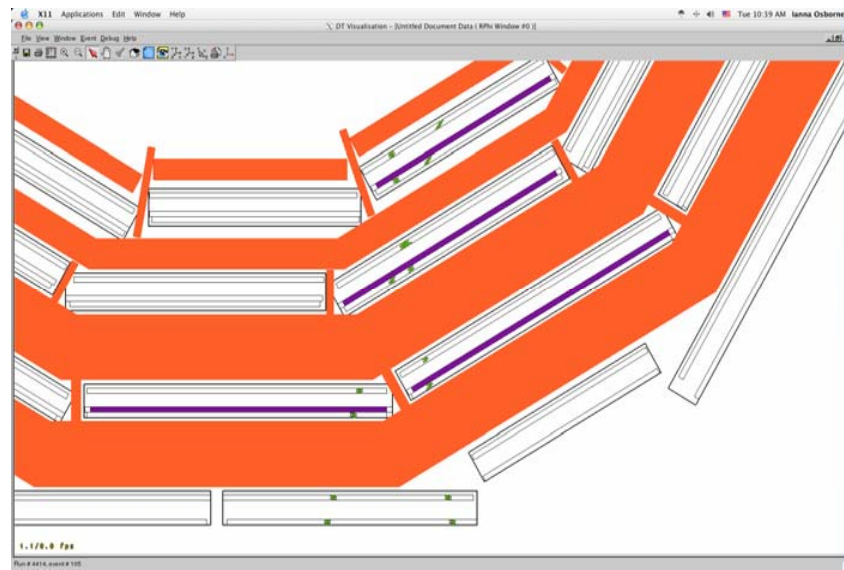
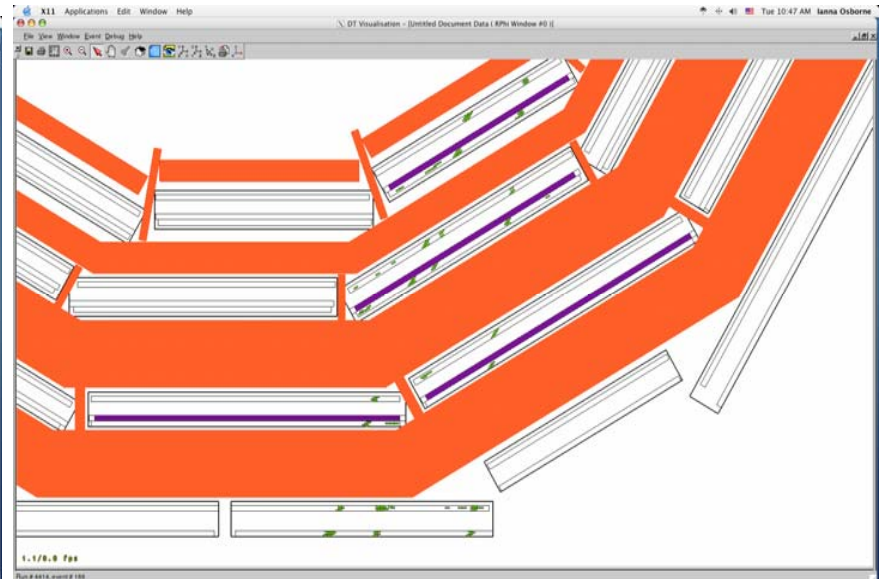
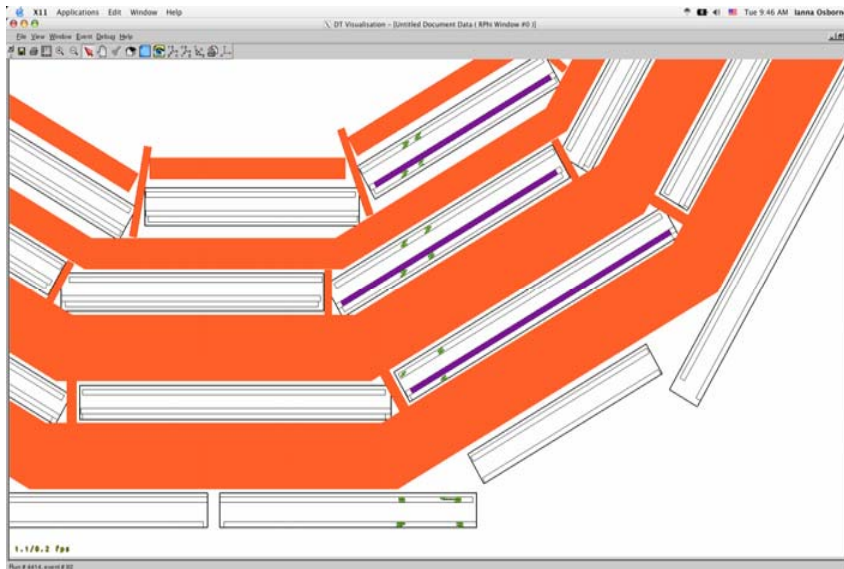
> 90% CSCs installed on  
YE disks.

3 out of  
5 YB  
wheels  
done  
(DTs,  
RPCs)





# Cosmics in two DT sectors

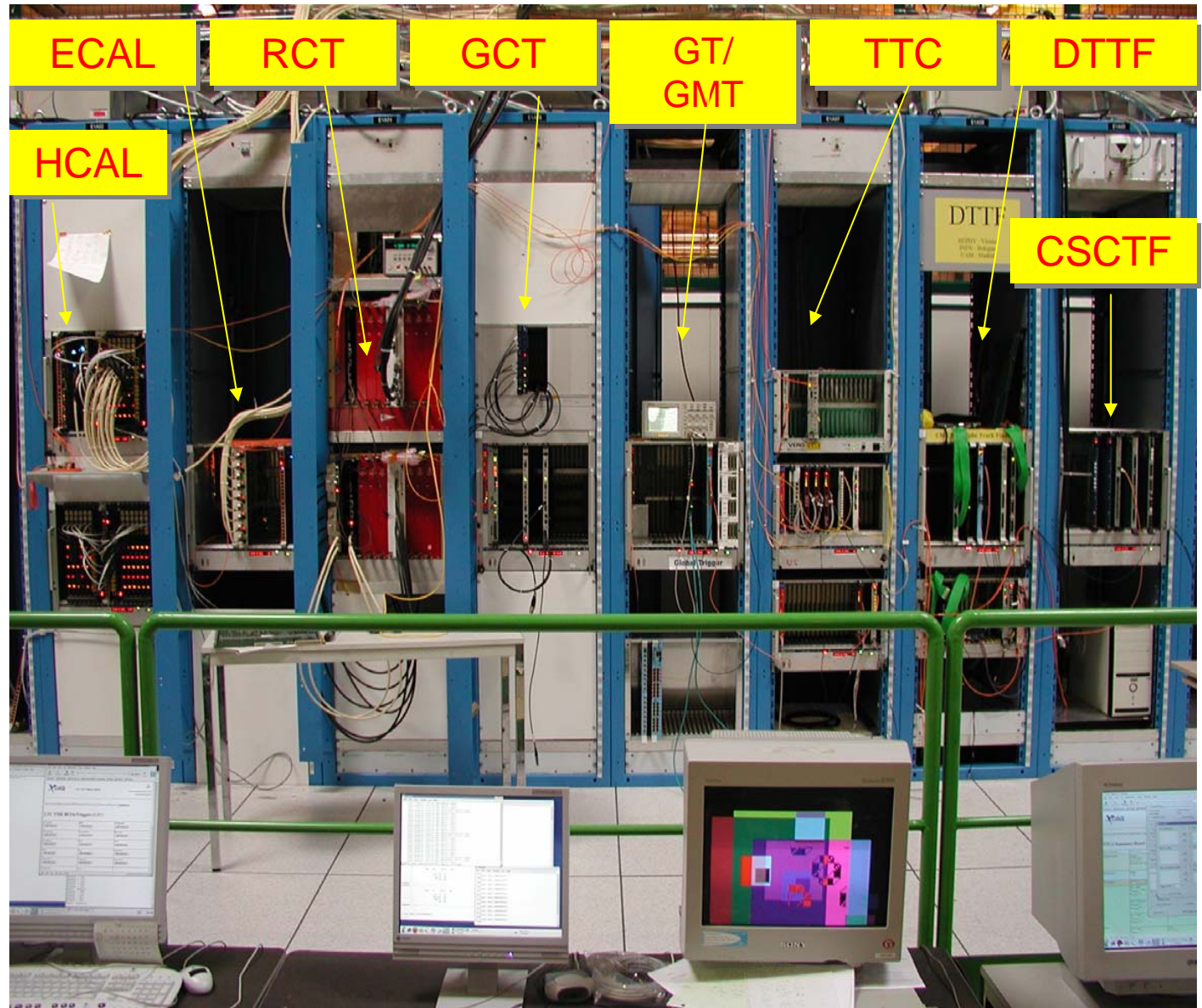


## Commissioning and burn-in of electronics, power supplies



## Large scale integration tests:

- Calorimeter Trigger
- Muon Trigger
- Global Trigger



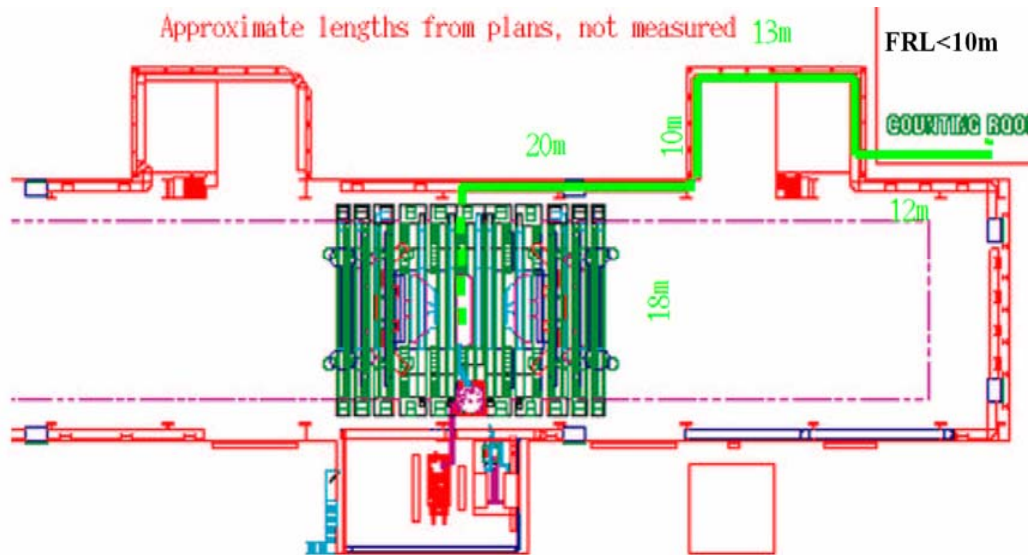




# New Global Calorimeter Trigger (GCT)

- ❑ Original GCT design was technically challenging (very high speed data transfer between many boards ~ 3GB/s)
- ❑ Major revision Jan 2006 (large FPGAs, optical links, ...)
- ❑ A new GCT team has been put together with C. Foudas as Project Manager, G. Hall as Resources Manager, Jim Brooke as Software Coordinator and M. Stettler as System Engineer.
- ❑ Schedule: The new GCT should be delivered for June 2007.
- ❑ LHCC March: “The schedule is tight but feasible... We strongly support these actions, and look forward to a progress report at the LHCC comprehensive review of CMS this June.”

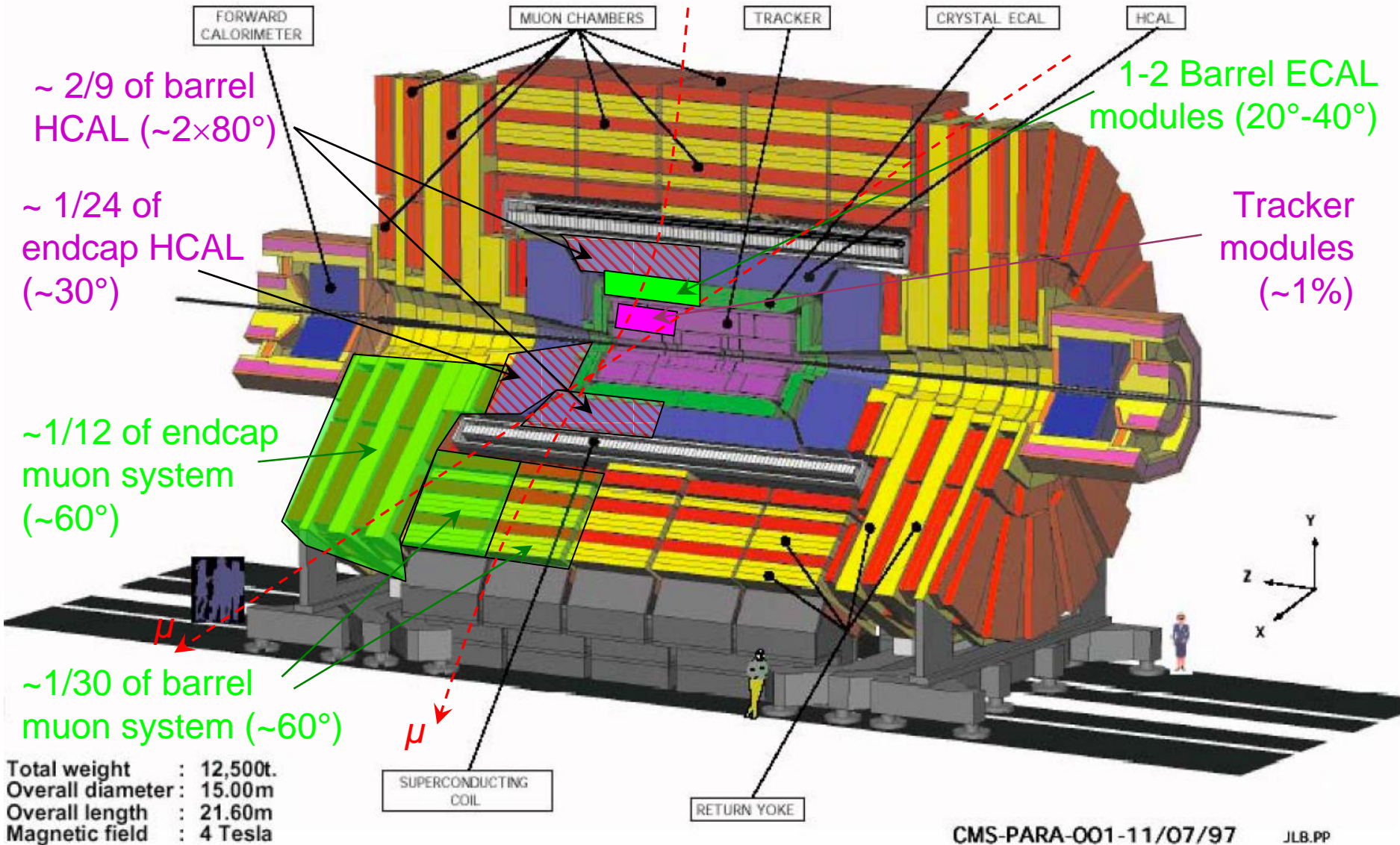
- ❑ Start ramping the magnet to the nominal field in June.
- ❑ Mid-05 scope increased - all detectors to participate incl. central DAQ, and use software in new framework (CPT folded-in)

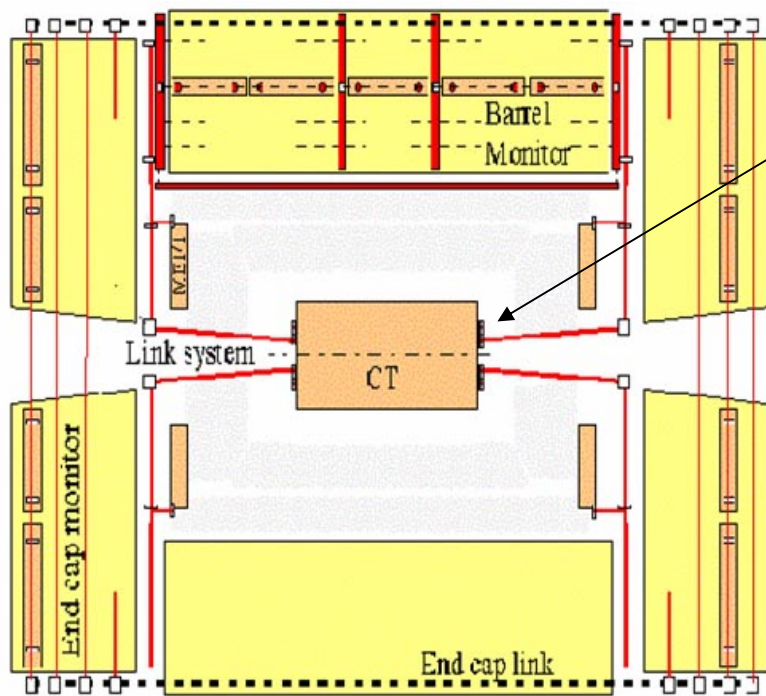


- ❑ Magnet commissioning and mapping (First operation of the magnet)
- ❑ Integration Plan Validation (First closing of the detector)
- ❑ Sub-Detector technical verification. Test Alignment system.
- ❑ Check entire detector-electronics-DAQ-CPT chain

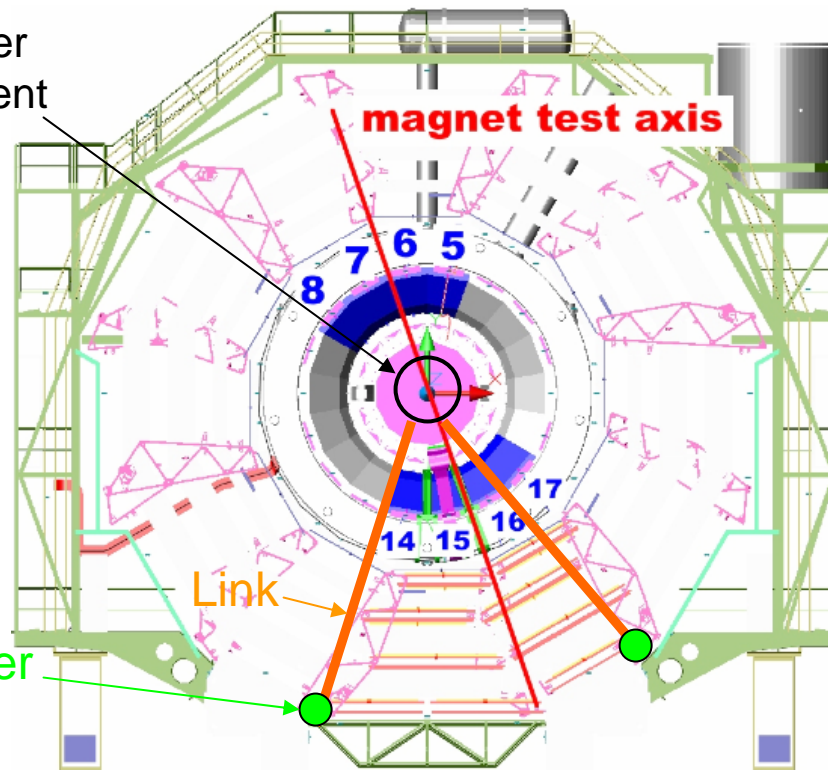


# The Cosmic Challenge Detector



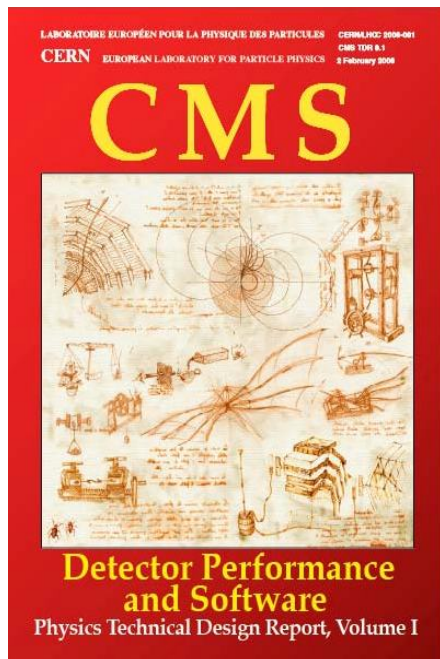


Tracker alignment ring



- ❑ Monitor iron deformation (O(few cm)!); verify dynamic range
- ❑ Check stability of the Muon system.
- ❑ Compare with cosmic track alignment at various fields (including  $B=0$ )

## □ Physics TDR – Volume I (Feb 06)



- Submitted LHCC: 2 Feb 06.
- Detector Performance and Software
- 548 pages, 553 figures
- Browseable PDF version and picture gallery:

<http://cmsdoc.cern.ch/cms/cpt/tdr/>

## □ Magnet test and cosmic challenge, MTCC (May-Aug 06)

- Take cosmics data with new Event Data Model (EDM) and new Framework: CMSSW \_0\_5\_0



# Preparing for Physics (2)

## □ **Physics TDR – Volume II (Jun 06)**

- Complete Analysis Examples (benchmark channels, eg:  $H \rightarrow \gamma\gamma$ )
- Physics Reach at  $10\text{fb}^{-1}$  and  $30\text{fb}^{-1}$

## □ **Computing, Software and Analysis challenge, CSA06 (Oct-Nov 06)**

- “Receive” from HLT (previously run) events with online tag (HLT decision)
- Run local “calibration” job to get constants for Tier-0 prodn
- O(50-100) million event production at Tier-0
- Split into physics datasets (say 3-5)
- Distribution of FEVT to participating Tier-1s
- Calibration jobs on FEVT at some Tier-1s
- Local creation of AOD
- Distribution of AOD to all participating Tier-1s
- Physics jobs on AOD at some Tier-1s
- Skim jobs at some Tier-1s
- Physics jobs on skimmed data at some Tier-2s



# Preparing for Physics (3)

## □ **Physics TDR – Volume III (Jan 07)**

- **High-Level trigger**
- **Startup procedures: prepare for first collisions in 2007**
- **Trigger tables: from  $10^{29}$  to  $10^{32}$**
- **Primary datasets: first definition of online streams**

## □ **Heavy Ion Physics – Addendum to Physics TDR (Jan 07)**

- **Prepare for first heavy ion collisions in 2008**



# WLCG Computing Resources (2008)

## Summary of Planned Tier-1 and Tier-2 Capacities Excluding CERN Tier-0 and CAF

Tier-1 Planning for 2008		ALICE	ATLAS	CMS	LHCb	SUM 2008
CPU - MSI2K	Offered	6.7	22.9	12.5	4.4	46.5
	TDR Requirements	12.3	24.0	15.2	4.4	55.9
	Balance	-46%	-5%	-18%	-0%	-17%
Disk - PBytes	Offered	2.8	12.7	5.7	2.2	23.4
	TDR Requirements	7.4	14.4	7.0	2.4	31.2
	Balance	-62%	-12%	-18%	-10%	-25%
Tape - PBytes	Offered	3.2	9.2	8.1	1.9	22.4
	TDR Requirements	6.9	9.0	16.7	2.1	34.7
	Balance	-54%	2%	-51%	-9%	-35%

Includes current planning for all Tier-1 centres

Tier-2 Planning for 2008		ALICE	ATLAS	CMS	LHCb	SUM 2008
CPU - MSI2K	Offered	5.6	19.6	17.2	4.4	46.8
	TDR Requirements	14.4	19.9	19.3	7.7	61.3
	Balance	-61%	-2%	-11%	-42%	-24%
Disk - PBytes	Offered	1.5	6.2	4.5	0.8	13
	TDR Requirements	3.5	8.7	4.9	0.023	17.1
	Balance	-58%	-29%	-8%	n/a	-24%

# Tier-2 federations - Included(expected)	15 (17)	23 (31)	23 (26)	11 (12)	38 (49)
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# CMS Computing Model

## ❑ Concern:

- ❑ A number of CMS T1s have pledged capacities < nominal CMS T1
- ❑ Pledged tape ~ 50% of that required
- ❑ Effectiveness of CMS Computing Model may be compromised.

## ❑ ACTIONS:

### ❑ Work with CERN Management, RRB, LHCC and WLCG

- ❑ LHCC has requested 'White Paper' for May meeting
- ❑ WLCG Overview Board has requested info from all 4 expts about T2/T1 connexions.

### ❑ Work with all WLCG Funding Agencies

- ❑ Only ~ 60% of CMS comes from candidate Tier 1 countries
- ❑ European Funding Agencies pledge pro-rata but US does NOT !

### ❑ Work with Tier 2 centres

- ❑ All Tier 2 must connect to a Tier 1. 'Foreign' Tier-2s should enter into agreement with a Tier 1 and should be encouraged to contribute resources at Tier 1.



# CMS Schedule v34.4

**Need to recover ~ 6 weeks after YB0 lowering in order to maintain target date of 30 Jun 07 for first beam circulation.**

Magnet closed:	May 06
Magnet test/cosmic challenge:	Jun-Aug 06
EB+ installation	Aug 06 SX5
USC ready for crates:	April-May 06
UXC cable chains installed	April 06-Jun 06
HF lowering:	July 06
YE+/YB+ cable chains cabled	June 06
YE3+ lowering start	Aug 06
UXC ready for crates	Jul 06
First connection to USC	Aug-Sep 06
YB0 lowered	Nov 06
Tracker installation	Jan-Feb 07
ECAL/Tracker cabling complete	Apr-May 07
Heavy lowering complete	Feb-Mar 07
Initial CMS ready for beam	30 Jun 07



# Conclusion

## □ CMS Construction continues to make good progress

- MTCC (detector-electronics-DAQ-CPT chain) i.e. low rate data from Pt5 to desktop
- Lowering and hardware commissioning in UXC, USC in 2nd half of 2006

## □ Commissioning for Physics:

- Putting in place final software: Cross-project Software Readiness Reviews.
- CSA06 exercise 24/7 bulk distribution of data and analysis i.e. T0 to desktop.
- Physics TDRs, vol3: Startup, HLT ... detailed scenario of physics at startup and into 2008.

## □ CMS Schedule

- Need to recover ~6 weeks after YB0 lowering in order to maintain target date of 30 Jun 07 for first beam circulation.

**CMS initial detector will be ready for collisions in 2007.**



CERN-RRB-2006-046

## **CMS Schedule**

“...The overall schedule remains very tight and challenging as delays have reduced the contingency in the schedule. To consolidate the schedule, settle the crystal procurement issues, and implement the new Tracker integration plan, CMS will soon need the 4 MCHF requested from the Resource Review Board.”



# CMS

## Financial Plan

Compact Muon Solenoid



# Additional Funds Request

No new answers since RRB21 (Oct05),

except PSI and RDMS-Russia

Funding Agency	Guideline	Committed /Best Effort
Austria	275	
Belgium-FNRS	150	150
Belgium-FWO	150	150
Brazil		
Bulgaria	27	
CERN	4,800	4,800
China	300	300
Croatia	20	20
Cyprus	43	
Estonia	6	6
Finland	300	300
France-CEA	445	445
France-IN2P3	2,000	2,000
Germany	1,100	1,100
Greece	305	
Hungary	65	
India	500	500
Iran	74	
Ireland		

Italy	5,000	4,000
Korea	189	147
Mexico		
New Zealand		
Pakistan	149	149
Poland	183	
Portugal	140	140
RDMS-DMS		
<b>RDMS-Russia</b>	<b>7,800</b>	
Serbia	24	
Spain	450	450
Switzerland-ETHZ		
Switzerland-PSI	500	
Switzerland-UNIV	200	200
Taipei	167	
Turkey	65	
United Kingdom	2,300	1,300
USA-DOE/NSF	4,750	4,750
<b>TOTAL</b>	<b>32,477</b>	<b>28,707</b>

**Missing funds: 32.5 - 28.7 = 3.8 MCHF + ?**



# ECAL Crystals Request (kCHF)

CERN has advanced the money and asks concerned Funding Agencies for a plan for reimbursement by 2010.

<b>Funding Agency</b>	<b>Request</b>	<b>Committed/ Best Effort</b>	<b>Still Requested</b>
CERN	4,800	4,800	
France-IN2P3	1,500	1,500	
India	500	500	
Italy	1,500	1,000	500
<b>RDMS-Russia</b>	<b>7,800</b>		
United Kingdom	2,300	1,300	1,000
USA-DOE/NSF	3,500	3,500	
<b>TOTAL</b>	<b>21,900</b>	<b>20,400</b>	<b>1,500</b>

Russian Ministry has agreed to contribute only 1500 EE crystals.  
**Funding for 5500 EE crystals has to be found.**  
Report in October.



# Tracker request (kCHF)

<b>Funding Agency</b>	<b>Request</b>	<b>Committed/ Best Effort</b>
Belgium-FNRS	150	150
Belgium-FWO	550	550
Finland	300	300
France-IN2P3	500	500
Germany	700	700
Italy	1,500	1,000
USA-DOE/NSF	1,250	1,250
<b>TOTAL</b>	<b>4,950</b>	<b>4,450</b>

As presented at  
Oct05 RRB

500 kCHF are missing from the present request (Oct 05).

Note that the 550 kCHF from Belgium FWO comprises 400 kCHF from CTC1 (Request from Oct 02) and 150 kCHF from the new request (Oct 05).

**Availability of sufficient manpower at CERN will be crucial for timely completion of the tracker.**





# Common Project

<b>Funding Agency</b>	<b>Request</b>	<b>Committed /Best Effort</b>	<b>Still requested</b>
Austria	275		275
Bulgaria	27		27
China	300	300	
Croatia	20	20	
Cyprus	43		43
Estonia	6	6	
France-CEA	445	445	
Greece	305		305
Hungary	65		65
Iran	74		74
Korea	189	147	42
Pakistan	149	149	
Poland	183		183
Portugal	140	140	
Serbia	24		24
Switzerland-PSI	500		500
Switzerland-Univ	200	200	
Taipei	167		167
Turkey	65		65
<b>TOTAL</b>	<b>3,177</b>	<b>1,407</b>	<b>1,770</b>

As presented  
at Oct05 RRB

The missing funds amount to 1.8 MCHF. These funds are URGENTLY needed for timely delivery of CMS in 2007. We request the agencies to fully fulfil the requests made.



# Global Calorimeter Trigger (GCT)

- ❑ As stated in the Status Report on CMS Construction the Global Calorimeter Trigger (GCT) has to be constructed using more recent technology.
- ❑ The additional cost to completion for this project is foreseen to be around 1.6 MCHF.
- ❑ GCT is a UK deliverable and the UK groups have requested access to UK contingency funds from PPARC. This is under urgent consideration.



# DAQ Staging and Restoration

- ❑ The CMS DAQ system is modular and consists of 8 independent DAQ slices, which can handle each 12.5 kHz of Level 1 trigger rate. The cost of each DAQ slice is 2 MCHF.
- ❑ After the cost to completion review in Oct 02 we requested 63 MCHF extra funds and we got promises for 52 MCHF. This has forced us to stage 4 DAQ slices (8 MCHF).
- ❑ Recent Tracker extra costs forced us to stage another DAQ slice. Hence we propose to start with 3 DAQ slices for the first run in 2007. We have shown to the LHCC that limiting the L1 rate to 37.5 kHz does not compromise the initial physics programme.
- ❑ Plans to recover 5 DAQ slices include:
  - ❑ New collaborators (e.g. US\_NP, US\_NSF\_Cornell, DESY, one DAQ slice requested from each)
  - ❑ M&O A (2 DAQ slices) - already in forward projections of M&O Cat A



# Conclusion: Finances

- ❑ CMS currently misses pledges for 2.3 MCHF to complete the low luminosity detector (ECAL endcap excluded).
  - ❑ 0.5 MCHF for the Tracker.
  - ❑ 1.8 MCHF for common project (installation and commissioning).
- ❑ These funds are now urgently needed for a timely completion of the low luminosity detector. **CMS urges the Funding Agencies to fully fulfill the requests made in the April 2005 RRB.**
- ❑ The installation and Commissioning of sub-detectors will depend crucially on availability of manpower at CERN. Because of the nature of this work, some unforeseen manpower requests may have to be made.
- ❑ **A new financial problem has developed for the completion of the ECAL endcap crystal delivery. The CERN management, CMS management and the Funding Agencies need to address this problem.**